FEASIBILITY STUDY

TAPPAN TERMINAL SITE

Hastings-On-Hudson, New York
(Site Registry No. 3-60-015)

CONTRACT NO. D003600-3

Prepared For

New York State Department of Environmental Conservation

JULY 2000

FINAL

DRAFT

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A DIVISION OF WILLIAM F. COSULICH ASSOCIATES, P.C.

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FEASIBILITY STUDY REPORT

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HASTINGS-ON-HUDSON, NEW YORK

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PREPARED FOR

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

BY

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CONSULTING ENGINEERS
WOODBURY, NEW YORK

JULY 2000

TAPPAN TERMINAL SITE
FEASIBILITY STUDY REPORT

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Section 1

1.0 INTRODUCTION

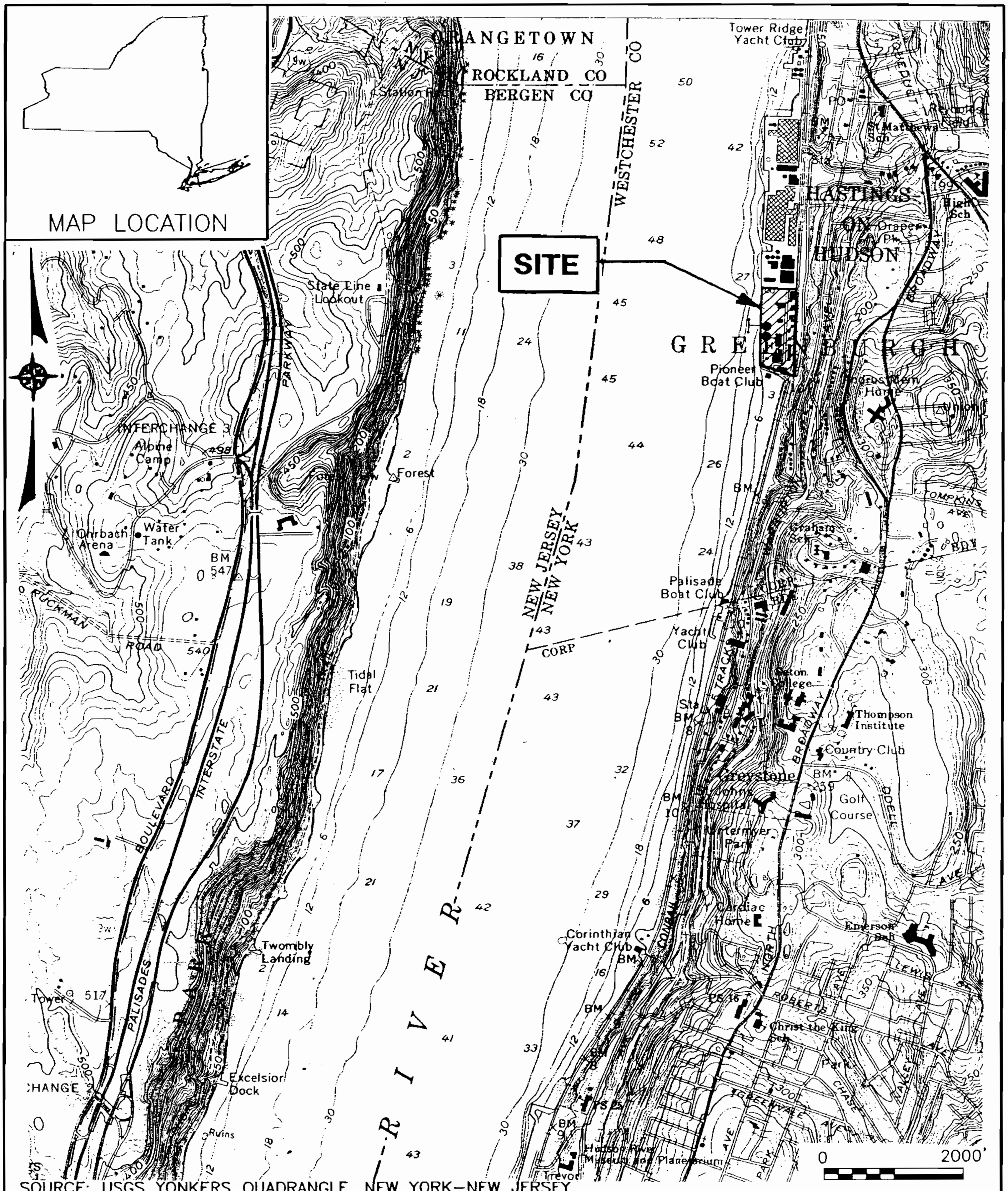
This section presents the purpose of the Feasibility Study for the Tappan Terminal Site, description and history of the site, summary of the remedial investigation and risk assessment results, remedial action objectives, and description and approach to the feasibility study.

1.1 Purpose and Site Background

As part of New York State's program to investigate and remediate hazardous waste sites, the New York State Department of Environmental Conservation (NYSDEC) issued a Work Assignment to Dvirka and Bartilucci Consulting Engineers of Woodbury, New York, under its Superfund Standby Contract with NYSDEC, to conduct a remedial investigation and feasibility study (RI/FS) for the Tappan Terminal Site located in Hastings-on-Hudson, Westchester County, New York (see Figure 1-1). The Tappan Terminal Site is presently listed as a Class 2 site in the NYSDEC Registry of Inactive Hazardous Waste Sites (Site No. 3-60-015). A Class 2 site is one that represents a "significant threat to public health or environment and some action is required."

The purpose of this RI/FS is to determine the nature, sources and extent of soil, groundwater and surface water sediment contamination; define pathways of contaminant migration; identify potential receptors and impacts; evaluate the need for corrective action; and identify, evaluate and select a remedial action plan for the site, which is the purpose of this feasibility study.

The Tappan Terminal Site is located on 15 acres of man-made fill adjacent to the Hudson River in Hastings-on-Hudson, New York (see Figure 1-1). The site is comprised of two property parcels. One parcel is owned by Mobil Oil Corporation and the other parcel is owned by the Uhlich Color Company, Inc. (see Figure 1-2). Access to the Tappan Terminal site is from Railroad Avenue at the southwest corner of the site. The Uhlich Color Company is an active pigment manufacturing facility. The Mobil property was formerly operated as a major oil storage facility and is currently vacant except of a small portion at the southwest corner that is



TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK

SITE LOCATION MAP

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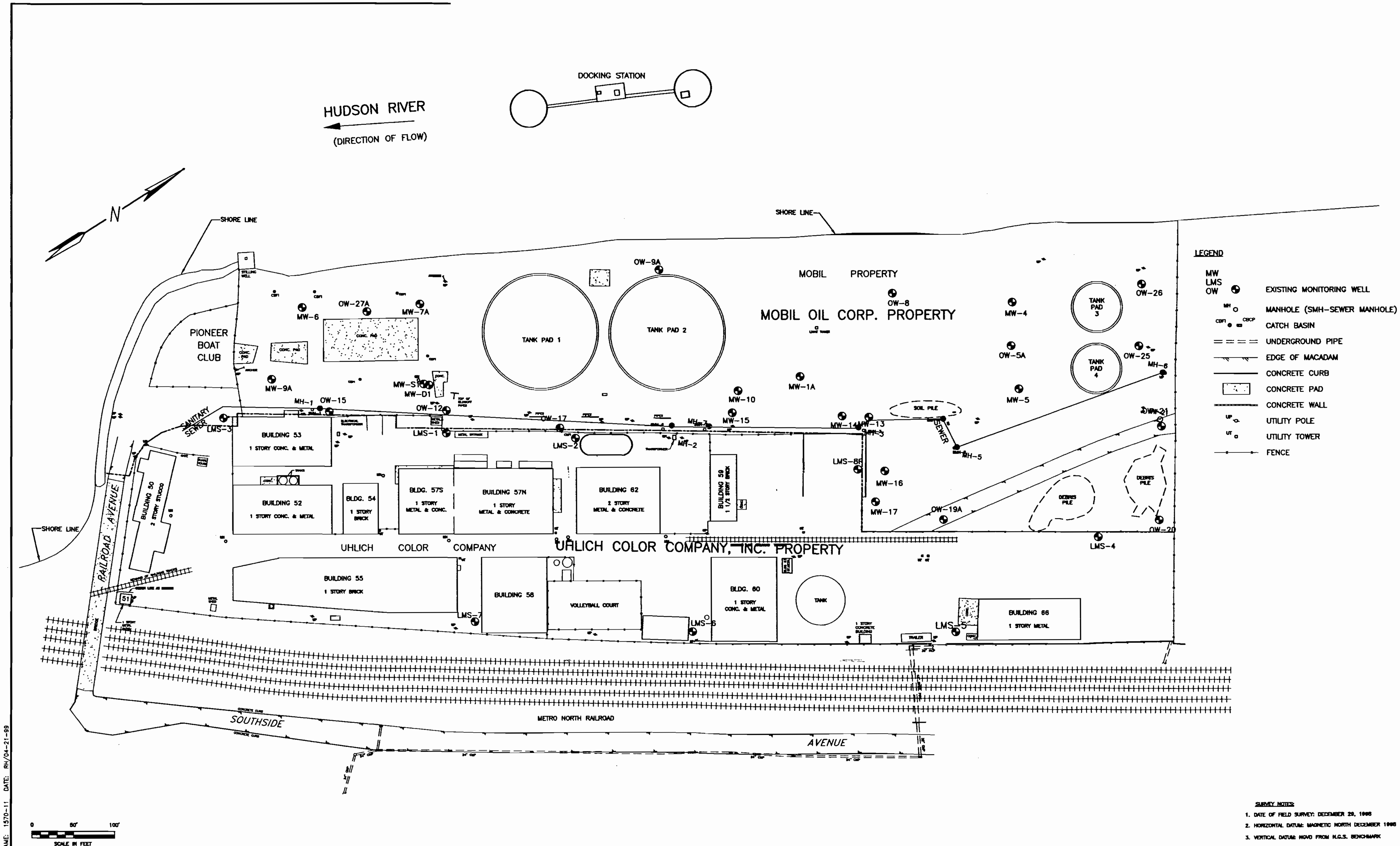
FIGURE 1-1



TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK

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SITE MAP

FIGURE 1-2

leased by the Pioneer Boat Club and operated as a boat launch and storage area. Oil storage operations on the Mobil property were discontinued in 1985.

The landmass at the site was constructed between 1868 and 1989 by progressive placement of man-made fill behind a series of intermediate bulkheads along the Hudson River. Filling began in the northeast corner of the property and progressed to the southwest. The fill material consisted of silt, sand and gravel mixed with bricks, concrete, stone, timber, ash, cinder, coal, slag, shells and other debris.

From 1897 to 1955, Zinsser and Company owned the site, which was a manufacturing facility for dyes, pigments and photographic processing chemicals. In 1955, Zinsser was acquired by Harshaw Chemical Company, which continued this manufacturing until 1961. Between 1961 and 1971, the Tappan Tanker Terminal operated the site as a fuel oil storage facility. The Uhlich Color Company began leasing the eastern portion of the site in 1964, and purchased that portion of the property from Tappan Tanker Terminal in 1975. Mobil leased the western portion of the site from 1970 to 1985.

In 1985, when Mobil closed the facility, several bulk storage violations and oil spills were discovered. Sampling and soil removal actions were conducted by Mobil under the Regional Oil Spill Program. After refusing to enter into an Order on Consent, Mobil entered into a Voluntary Agreement with NYSDEC to perform a remedial investigation and feasibility study for its parcel in September 1996. A remedial investigation report was submitted in April 1997, which indicated the need to further investigate the contamination on the Uhlich property. A draft feasibility study report was submitted to NYSDEC in July 1998, however the recommendations of the report have not been formally accepted by NYSDEC.

During negotiations between NYSDEC and the three known and viable potentially responsible parties (Mobil, Uhlich and Chevron) all denied liability for the release of contaminants and declined to undertake a remedial program for the site. A remedial investigation report was prepared by D&B for NYSDEC in September 1999. This feasibility study has been prepared based on the results of the remedial investigation and in accordance with the federal Comprehensive Emergency Response, Compensation and Liability Act (CERCLA), Superfund Amendments and Reauthorization Act (SARA) and the New York State Superfund Program, including the NYSDEC Technical and Administrative Guidance Memorandum (TAGM HWR-90-4030) for "Selection of Remedial Actions at Inactive Hazardous Waste Sites."

1.2 Remedial Investigation Results

The following is a summary of the findings and conclusions resulting from the remedial investigation conducted for the Tappan Terminal Site as a function of the media investigated. These findings and conclusions are based on comparison of the investigation results to standards, criteria and guidelines (SCGs) selected for the site. The results of the initial phase of the investigation for the site are described in the remedial investigation report dated September 1999. A supplemental investigation was performed in November 1999 to obtain additional information for preparation of this feasibility study. A summary of the results of this supplemental investigation are provided in Section 3.0 of this report.

Site Geology and Site Hydrogeology

The general stratigraphy of the site consists of four units. The uppermost unit consists of a manmade fill unit ranging in thickness from 10 to 20 feet. This fill unit consists predominantly of sand and silt size particles with some gravel and some clay. The fill is composed of ash, slag, glass, metal debris, wood, crushed stone, paper, coal, sawdust and brick fragments. Marine Grey silt underlies the manmade fill. The Marine Grey silt has been reported to be 10 to 40 feet thick with the thinner portions to the east. Basal sand deposits underlie the Marine Grey silt. This unit is reported to be between 10 and 70 feet thick. The basal sand unit in underlain by bedrock.

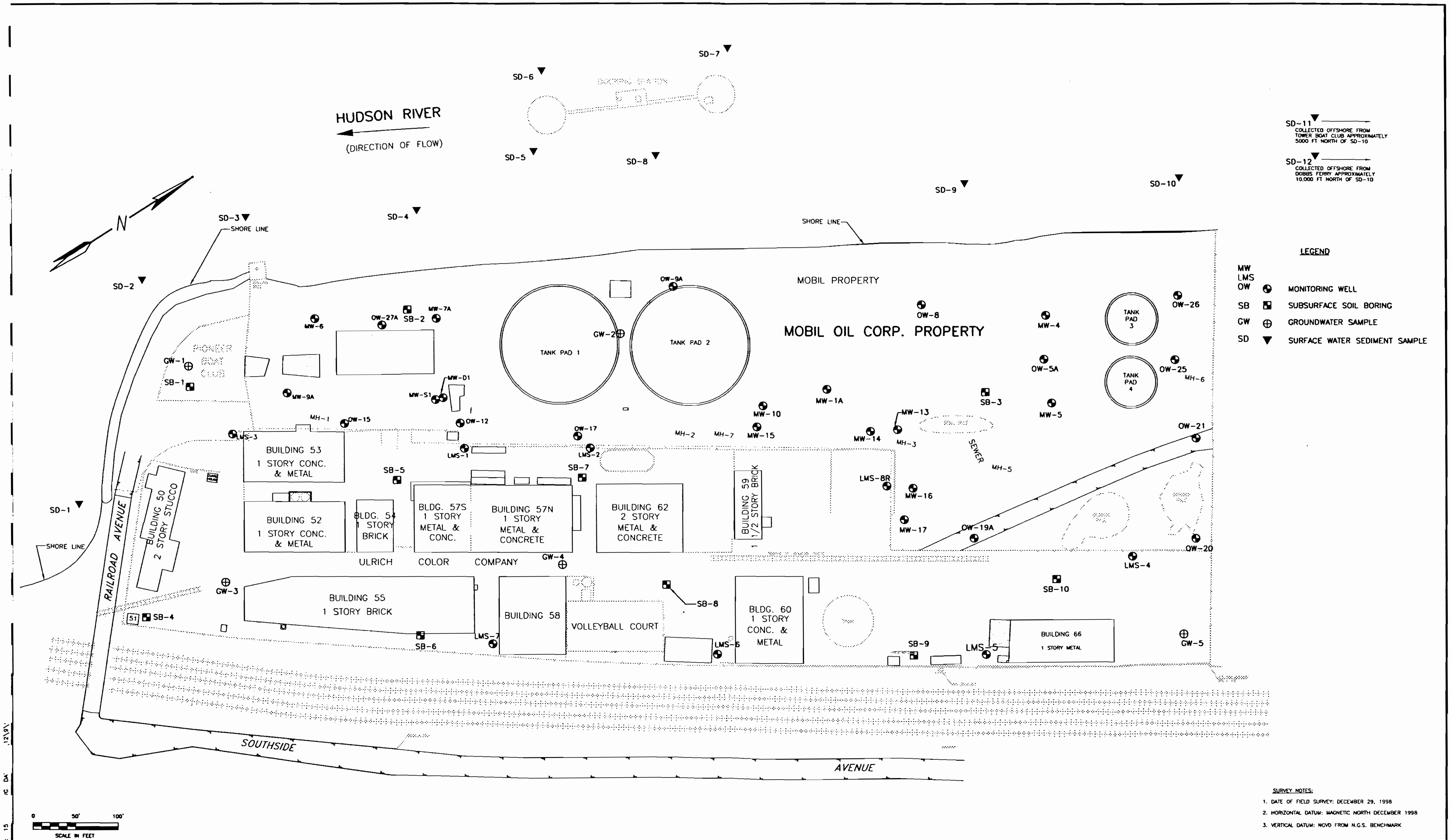
The depth to groundwater ranges between 2 and 7 feet below ground surface and flow is generally to the west toward the Hudson River. The Marine Grey silt is a low permeability aquitard that confines deep groundwater in the basal sand deposits and limits downward flow of shallow groundwater in the fill unit. Based on observations of the water table, the influence of the Hudson River tide on groundwater flow occurs within approximately 100 feet from the shoreline. Wells at a greater distance show no tidal influence. Figure 1-3 provides the locations of the monitoring wells on-site. The natural groundwater quality at the site is influenced by the influx of river water during high tides. Since there is a salt-water wedge that moves upstream during high tides, high concentrations of sodium and chloride flow into the site.

Surface Soil

Based upon the results of the remedial investigation, the contaminants of concern for the surface soils at the Tappan Terminal Site are carcinogenic polycyclic aromatic hydrocarbons (CaPAHs) and metals, with isolated areas of PCB contamination. Elevated concentrations of CaPAHs were found essentially in all areas of the site. As described above, fill used to create the site is likely the primary source of the CaPAHs. Higher concentrations of CaPAHs were found in samples collected immediately below asphalt surfaces, which likely result, in part, from the asphalt itself. Elevated levels of metals, such as arsenic, barium, copper, lead and zinc, also occur essentially throughout the site and are also attributable to the fill material. The PCB contamination, including elevated levels of Aroclor 1260, is likely attributable to the use of PCBs in wire manufacturing conducted by the Anaconda Corporation on the Harbor-at-Hastings (ARCO) site, which is adjacent to the Tappan Terminal Site. Aroclor 1260 has been identified as a widespread soil contaminant at the ARCO site.

Subsurface Soil

Subsurface soil contaminants include CaPAHs and metals essentially throughout the site. As discussed with the surface soil results, these exceedances are likely attributable to the fill material at the site. There are also several isolated areas of exceedances of SCGs for tetrachloroethene (PCE), trichloroethene (TCE), 1,2-dichloroethene (DCE), vinyl chloride and nitrobenzene. The concentrations of CaPAHs and metals are similar to those found in surface soils and were likely brought to the site in the fill material used to reclaim land from the Hudson River.



TAPPAN TERMINAL SITE
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SUBSURFACE SOIL, GROUNDWATER AND SEDIMENT SAMPLE LOCATION MAP

FIGURE 1-3

Chlorobenzene was detected at concentrations above the SCGs in subsurface soil samples from borings SB-5 and SB-7 (see Figure 1-3). These locations are adjacent to a suspected source area of chlorobenzene. Historic maps of the site during the operation of the Zinnser Company indicate the presence of a chlorobenzene storage tank on what is now the Mobil property. The tank was located southeast of the southern-most former tank pad near surface sample location SS-2. This area of chlorobenzene contaminated subsurface soil also corresponds with an area of chlorobenzene contaminated groundwater. Subsurface soil was likely contaminated from spills or leaks of chlorobenzene stored in the tank. Chlorobenzene in subsurface soils is of potential concern at the site due to exceedance of SCGs and migration into groundwater, as well as possible migration to the Hudson River.

Chlorinated solvents, including PCE, TCE, 1,2-DCE and vinyl chloride, have been identified in exceedance of SCGs at locations SB-5, SB-7 and SB-8 on the Uhlich property. The locations of solvent contaminated soils are between buildings that have been identified on the historic maps as a machine shop and still (near SB-8), and paint shop (near SB-7) where solvents may have been used.

Petroleum-like characteristics were observed in subsurface soil sample SB-3. This sample was collected from a location adjacent to an area where petroleum contaminated soil was excavated on the Mobil property. Although analysis failed to identify compounds in exceedance of SCGs, a number of hydrocarbon tentatively identified compounds were detected and the observed characteristics of this sample suggest that this area of the site may be of concern.

Groundwater

The predominant groundwater contaminant at the Tappan Terminal Site is chlorobenzene. A plume of chlorobenzene contaminated groundwater has been established in previous investigations and was confirmed by the results of this remedial investigation. The plume source appears to be near the former Zinnser chlorobenzene tank location and generally follows the abandoned sanitary sewer line on the Mobil property near the border with the Uhlich property. The highest concentrations of chlorobenzene are near the source tank location and along the sewer line. The plume extends outward from the sewer line in diminishing concentrations.

Benzene was identified in groundwater at concentrations slightly above SCGs. Benzene occurrences are largely coincident with chlorobenzene and occur along the abandoned sewer line. Other groundwater contaminants found at a frequency less than chlorobenzene and benzene, include 2-chlorophenol, 1,2-, 1,3- and 1,4-dichlorobenzene, phenols and naphthalene. These compounds are of some concern due to exceedances of SCGs, however the occurrence of the compounds appears isolated on the interior portions of the site and migration does not appear to be extensive.

Two pesticide compounds, 4,4'-DDD and Beta BHC were detected at levels above the Class GA groundwater standards in three and two wells respectively. No PCBs were detected above the Class GA groundwater standards in any of the groundwater samples collected. Pesticides were not detected above SCGs in on-site soils therefore, these contaminants are of minor concern due to the low and infrequent exceedances of SCGs. Several metals including antimony, arsenic, barium, copper, iron, lead, magnesium, manganese, selenium, sodium and thallium were detected at levels above Class GA groundwater standards in at least one sample collected during the remedial investigation. The levels of metals detected are likely the result of the industrial fill placed at the site.

Surface Water Sediment

Surface water sediment samples collected from the Hudson River adjacent to the Tappan Terminal Site contain CaPAHs and PCBs in exceedances of SCGs. The concentrations of these compounds are similar to those found in sediment samples collected from numerous locations in the lower Hudson River and are considered background for the river.

1.3 Risk Assessment Results

The purpose of the risk assessment is to evaluate the potential risks to human health and the environment associated with the Tappan Terminal Site. Risks were evaluated on the basis of the site environmental setting and information on the nature and extent of contamination. The assessment addresses the current and potential human contact with contaminants of concern at potential locations where human exposure could occur, and potential impacts to ecological receptors. The following is a summary of the findings and conclusions of the Baseline Human Health Risk Assessment prepared for the Tappan Terminal Site dated May 2000 and the ecology and wildlife habitat survey which is included in the remedial investigation.

1.3.1 Human Health Exposure Assessment

The risk assessment identifies the potential human exposure pathways that are of concern at the site and surrounding area, and the need for remediation. The assessment addressed possible human exposures to contaminants resulting from ingestion, inhalation, dermal contact and absorption. The assessment considered both current and hypothetical future exposures. Based on the results of the remedial investigation, the following exposure pathways are potentially complete at the present time and were evaluated quantitatively in the risk assessment.

- Oral, dermal and inhalation exposure of on-site workers to surface soil (Mobil property);
- Oral and dermal exposure of on-site workers to river sediment (Mobil property);
- Oral, dermal and inhalation exposure of Pioneer Boat Club members to surface soil; and
- Oral, dermal and inhalation exposure of Pioneer Boat Club members to river sediment (may not occur, but is assessed any way).

The following pathways are not necessarily complete and may never be complete, but were considered hypothetical future pathways and were quantified in the assessment:

- Oral, dermal and inhalation exposure of daily on-site workers to surface soil (Uhlich and Mobil properties);

- Oral, dermal and inhalation exposure of occasional on-site trespassers to surface soil (Mobil property; Uhlich property is currently covered predominately by buildings and pavement, and likely to remain so. If it is re-developed, the recreational, worker and residential scenarios would cover hypothetical risks);

- Oral, dermal and inhalation exposure of recreational users to surface soil (Mobil and Uhlich properties; assumes development of both properties for recreational use);

- Oral, dermal and inhalation exposure of hypothetical on-site residents to surface soil (Mobil and Uhlich properties; assumes development for residential use);

- Oral and dermal exposure of hypothetical on-site residents to river sediment (Mobil property);

- Oral and dermal exposure of hypothetical recreational users to river sediment (Mobil property);

- Oral exposure of hypothetical residents to homegrown produce (Mobil and Uhlich properties);

- Oral, dermal and inhalation exposure of hypothetical excavation workers to on-site subsurface soil (Mobil and Uhlich properties); and

- Dermal and inhalation exposure of hypothetical excavation workers to groundwater in an open excavation (Mobil and Uhlich properties).

Details on the exposure profiles, quantification of exposure and toxicity assessment are provided in the risk assessment.

It is not possible to evaluate the risks associated with every chemical of potential interest detected at any site due to the lack of reference toxicity information for every chemical. Therefore, the numeric estimates of risk presented for the site were based on the chemicals for which reference toxicity information is available. The United States Environmental Protection Agency (USEPA) and other regulatory agencies have not developed specific reference toxicity information for lead due to the lack of a threshold for toxic effects, and have developed separate models and methodologies for assessing risks associated with lead. Therefore, risks associated with exposure to lead were considered and discussed separately.

Site-specific Risks for Chemicals Other than Lead

Risks associated with each media are summarized in Table 1-1 for the Mobil property and in Table 1-2 for the Uhlich property. The tables highlight hazard index (HI) values in excess of one, and cancer risks greater than or equal to one-in-one-million. The New York State Department of Health (NYSDOH) has developed general qualitative descriptors to assist in characterizing the level of concern posed by exposure to chemical contaminants as follows: A HI value: 1) less than or equal to one reflects minimal risk; 2) greater than 1 but less than or equal to 5 reflects low risk; 3) greater than 5 but less than or equal to 10 reflects moderate risk; and 4) greater than 10 reflects high risk.

The NYSDOH has developed qualitative descriptors to rank cancer risk as follows. Risks 1) less than or equal to on-in-one-million (1E-06) are "very low"; 2) greater than one-in-one-million (1E-06) to less than one-in-ten-thousand (1E-04) are "low"; 3) risks of one-in-ten-thousand (1E-04) to one-in-one-thousand (1E-03) are "moderate"; 4) risks of one-in-one-thousand (1E-03) to less than one-in-ten (1E-01) are "high"; and 5) risks greater than one-in-ten (1E-01) are "very high."

As shown in the tables, most of the noncarcinogenic risk estimates have HI values less than one, and as such, fall under the NYSDOH classification of 'minimal risk." The only exposure pathways for both properties having HI values in excess of one are those involving ingestion of garden produce by hypothetical residents, dermal contact with groundwater (hypothetical excavation worker: "low risk" due to chlorobenzene) and incidental ingestion of surface soil by hypothetical young child residents ("low risk"). In the case of garden produce, the concentrations of inorganic chemicals of potential interest, particularly arsenic, cadmium and mercury, are responsible for the elevated HI values.

As shown in the tables, the estimated excess lifetime cancer risks are "very low" to "low" (less than one-in-ten-thousand) for all receptors on both properties except in the case of hypothetical on-site residents. The only exposure pathways having "moderate" excess lifetime cancer risks (risks greater than or equal to one-in-ten-thousand (1E-04)) are those pathways for

TABLE 1-1
TAPPAN TERMINAL SITE
HUMAN HEALTH RISK ASSESSMENT

SUMMARY OF RISKS FOR THE MOBIL PROPERTY

Scenario Receptor/Medium	Route	Table Number	Non-Carcinogenic Risk HI	Class [3]	Risk Drivers [1]	Carcinogenic Risk Risk	Class [3]	Risk Drivers [2]
Current Users of Pioneer Boat Club Launch								
Surface Soil	oral	A-5	4.62E-02	minimal		2.71E-06	low	As
	dermal	A-6	3.26E-02	minimal		3.11E-06	low	As
	inhalation	A-19	NQ			2.80E-07	very low	
Sediment	oral	A-27	1.01E-05	minimal		8.82E-08	very low	
	dermal	A-28	1.01E-05	minimal		1.31E-07	very low	
Total Risk			8.E-02	minimal		6.E-06	low	
Current On-Site Workers								
Surface Soil	oral	A-17	1.07E-02	minimal		5.21E-07	very low	
	dermal	A-18	7.52E-03	minimal		2.42E-07	very low	
	inhalation	A-19	NQ			2.80E-07	very low	
Sediment	oral	A-39	2.34E-06	minimal		1.70E-08	very low	
	dermal	A-40	2.34E-06	minimal		2.53E-08	very low	
Total Risk			2.E-02	minimal		1.E-06	very low	

Notes:

[1] Chemicals of potential interest contributing to a pathway HI greater than 1

[2] Chemicals of potential interest contributing the most risk when the pathway cancer risk is greater than 1E-6

[3] NYSDEC/NYSDOH qualitative classifications of risk based on quantitative estimate

Sb =Antimony; As = arsenic; Ba = barium; Th = thallium; Va = vanadium

Carc. PAHs = carcinogenic PAHs; PCB = polychlorinated biphenyls = Aroclor 1260

TABLE 1-1 (continued)
TAPPAN TERMINAL SITE
HUMAN HEALTH RISK ASSESSMENT

SUMMARY OF RISKS FOR THE MOBIL PROPERTY

Scenario		Table	Non-Carcinogenic Risk			Carcinogenic Risk		
Receptor/Medium	**Route**	**Number**	**HI**		**Risk Drivers[1]**	**Risk**	**Classification [3]**	**Risk Drivers [2]**
			Hypothetical On-Site Residents					
Combined Child/Adult Exposure								
Surface Soil	oral	A-2	8.29E-01	minimal		4.87E-05	low	As; Carc. PAHs; PCB
	dermal	A-3	3.44E-01	minimal		9.51E-06	low	As; Carc. PAHs; PCB
	inhalation	A-19	NQ			2.80E-07	very low	
Sediment	oral	A-24	1.82E-04	minimal		1.58E-06	low	Carc. Ahs
	dermal	A-25	7.74E-05	minimal		1.00E-06	very low	
Garden Produce	oral	A-22	**4.44**	low	inorganics	**2.47E-04**	**moderate**	As; Carc. PAHs; dieldrin; PCB
Total Risk			**6**	**moderate**		**3.E-04**	**moderate**	
Young Child (0-6 yr.)								
Surface Soil	oral	A-1	**2.9**	**low**	inorganics	NQ	NA	NA
	dermal	A-4	3.68E-01	minimal		NQ	NA	NA
	inhalation	A-19	NQ			NQ	NA	NA
Sediment	oral	A-23	6.63E-04	minimal		NQ	NA	NA
	dermal	A-26	1.14E-04	minimal		NQ	NA	NA
Garden Produce	oral	A-21	**4.44**	**low**	inorganics	NQ	NA	NA
Total Risk			**8**	**moderate**		**NQ**	**NA**	
			Hypothetical Recreational Users					
Combined Child/Adult Exposure								
Surface Soil	oral	A-8	1.23E-01	minimal		7.23E-06	low	As; Carc. PAHs
	dermal	A-9	3.70E-02	minimal		1.43E-06	low	As; Carc. PAHs
	inhalation	A-19	NQ			2.80E-07	very low	
Sediment	oral	A-30	2.70E-05	minimal		2.35E-07	very low	
	dermal	A-31	1.15E-05	minimal		1.49E-07	very low	
Total Risk			2.E-01	minimal		9.E-06	low	
Young Child (0-6 yr.)								
Surface Soil	oral	A-7	9.31E-01	minimal		NQ	NA	
	dermal	A-10	1.71E-01	minimal		NQ	NA	
	inhalation	A-19	NQ			NQ	NA	
Sediment	oral	A-29	9.45E-05	minimal		NQ	NA	
	dermal	A-32	1.70E-05			NQ	NA	
Total Risk			1.E+00	minimal		**NQ**	**NA**	

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TABLE 1-1 (continued)
TAPPAN TERMINAL SITE
HUMAN HEALTH RISK ASSESSMENT

SUMMARY OF RISKS FOR THE MOBIL PROPERTY

Scenario		Table	Non-Carcinogenic Risk			Carcinogenic Risk		
Receptor/Medium	**Route**	**Number**	**HI**		**Risk Drivers[1]**	**Risk**	**Classification [3]**	**Risk Drivers [2]**
Hypothetical Occasional Trespassers								
Older Child (8-18 yrs.)								
Surface Soil	oral	A-11	3.23E-02	minimal		6.32E-07	very low	
	dermal	A-13	1.69E-02	minimal		2.17E-07	very low	
	inhalation	A-19	NQ			2.80E-07	very low	
Sediment	oral	A-33	7.09E-06	minimal		2.06E-08	very low	
	dermal	A-35	5.25E-06	minimal		2.27E-08	very low	
Total Risk			4.92E-02	minimal		1.17E-06	very low	
Adult								
Surface Soil	oral	A-12	2.31E-02	minimal		1.36E-06	low	As
	dermal	A-14	1.63E-02	minimal		6.29E-07	very low	
	inhalation	A-19	NQ			2.80E-07	very low	
Sediment	oral	A-34	5.06E-06	minimal		4.41E-08	very low	
	dermal	A-36	5.07E-06	minimal		6.57E-08	very low	
Total Risk			4.E-02	minimal		2.E-06	low	
Hypothetical Future On-Site Workers								
Surface Soil	oral	A-15	2.22E-01	minimal		1.09E-05	low	As; Carc. PAHs
	dermal	A-16	1.57E-01	minimal		5.03E-06	low	Carc. PAHs; PCB
	inhalation	A-19	NQ			2.80E-07	very low	
Sediment	oral	A-37	4.87E-05	minimal		3.53E-07	very low	
	dermal	A-38	4.87E-05	minimal		5.26E-07	very low	
Total Risk			4.E-01	minimal		2.E-05	low	
Hypothetical Excavation Workers								
Sub-surface soil	oral	A-41	1.38E-01	minimal		2.33E-07	very low	
	dermal	A-42	9.41E-03	minimal		1.01E-07	very low	
	inhalation	A-43	8.80E-06	minimal		5.00E-10	very low	
Groundwater	dermal	A-44	**3.06**	**low**	Chlorobenzene	3.62E-08	very low	
	inhalation	A-45	9.00E-02	minimal		2.16E-07	very low	
Total Risk			**3.E+00**	**low**		6.E-07	very low	

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TABLE 1-2
TAPPAN TERMINAL SITE
HUMAN HEALTH RISK ASSESSMENT

SUMMARY OF RISKS FOR THE UHLICH PROPERTY

Scenario Receptor/Medium	Route	Table Number	Non-Carcinogenic Risk HI	Class [3]	Risk Drivers [1]	Carcinogenic Risk Risk	Class [3]	Risk Drivers [2]
Hypothetical Future On-Site Workers								
Surface Soil	oral	B-9	1.47E-01	minimal		2.87E-05	low	Carc. PAH; As
	dermal	B-10	1.91E-01	minimal		3.08E-05	low	Carc. PAH; As
	inhalation	B-11	3.30E-06	minimal		6.10E-07	very low	
Total Risk			3.E-01	minimal		6.E-05	low	
Hypothetical Excavation Workers								
Sub-surface soil	oral	B-15	6.20E-01	minimal		2.34E-07	very low	
	dermal	B-16	7.48E-02	minimal		8.20E-08	very low	
	inhalation	B-17	1.10E-04	minimal		9.10E-07	very low	
Groundwater	dermal	B-18	**1.14**	**low**	Chlorobenzene	3.38E-08	very low	
	inhalation	B-19	5.40E-02	minimal		2.11E-07	very low	
Total Risk			**2.E+00**	**low**		1.E-06	very low	
Hypothetical On-Site Residents								
Combined Child/Adult Exposure								
Surface Soil	oral	B-2	5.50E-01	minimal		**1.28E-04**	**moderate**	Car.PAH; As; PCB
	dermal	B-3	2.82E-01	minimal		4.87E-05	low	Car. PAH; PCB
	inhalation	B-11	3.30E-06	minimal		6.10E-07	very low	
Garden Produce	oral	B-14	**2.81**	**low**	inorganics	**7.75E-04**	**moderate**	Carc. PAH; As; PCB
Total Risk			4	low		**1.E-03**	**high**	
Young Child (0-6 yr.)								
Surface Soil	oral	B-1	**1.92E+00**	**low**	inorganics	NQ	NA	
	dermal	B-4	4.48E-01	minimal		NQ	NA	
	inhalation	B-11	3.30E-06	minimal		NQ	NA	
Garden Produce	oral	B-13	**2.81**	**low**	inorganics	NQ	NA	
Total Risk			**5**	**low**		NQ	NA	
Hypothetical Recreational Users								
Combined Child/Adult Exposure								
Surface Soil	oral	B-6	8.16E-02	minimal		1.91E-05	low	Carc. PAH; As
	dermal	B-7	4.51E-02	minimal		7.39E-06	low	Carc. PAH
	inhalation	B-11	3.30E-06	minimal		6.10E-07	very low	
Total Risk			1.E-01	minimal		3.E-05	low	
Young Child (0-6 yr.)								
Surface Soil	oral	B-5	2.86E-01	minimal		NQ	NA	
	dermal	B-8	6.66E-02	minimal		NQ	NA	
	inhalation	B-11	3.30E-06	minimal		NQ	NA	
Total Risk			4.E-01	minimal		NQ	NA	

Notes:

[1] Chemicals of potential interest contributing to a pathway HI greater than 1

[2] Chemicals of potential interest contributing the most risk when the pathway cancer risk is greater than 1E-6

[3] NYSDEC/NYSDOH qualitative classifications of risk based on quantitative estimate

Carc. PAHs = carcinogenic PAHs; As = arsenic; PCB = polychlorinated biphenyls = aroclor 1260

The lead concentrations detected in surface soil on the Mobil property range from 13.8 to 1,320 mg/kg, with an average concentration of 512.6 mg/kg and an upper 95% confidence limit of 741 mg/kg. The lead concentrations detected in surface soil on the Uhlich property range from 60 to 972 mg/kg, with an average concentration of 279 mg/kg and an upper 95% confidence limit of 434 mg/kg.

1.3.2 Ecology and Wildlife Habitat Survey

A habitat based assessment was performed for the site and is included in the remedial investigation report dated September 1999. The purpose of the assessment is to provide a description of the existing ecology of the site and vicinity including a site specific description of major habitat types with associated fish and wildlife populations, and identify any other significant on-site resources.

With respect to potential impacts from related site contaminants, despite the removal of the fuel storage tanks from the property, the revegetation of this area has been slow compared to the surrounding areas. Vegetative encroachment has occurred from the edges of the unvegetated area. Revegetation has otherwise been limited to rhizomal movement, primarily by common reed. Limiting factors that could be naturally deterring revegetation of this area are the limited nutrients in the sandy soils and the shallow depth to a concrete slab beneath the sand (less than 1 foot in some areas). Another limiting factor could be the decompression of these sediments from heavy loading over time. Each of these factors would slow plant invasion and growth, but should not result in an area like this to remain largely devoid of vegetation. This area would warrant additional investigation as to the influencing factors on vegetative growth.

Although observations to evaluate aquatic environmental stress were not possible, information on fish species collected from the Hudson River in this area by the NYSDEC and the known concentration of polychlorinated biphenyls associated with sediments off the adjacent ARCO property to the north, it is likely that some environmental stress is placed on the ecosystem for bottom dwelling organisms. These stresses can result in both lethal and sublethal impacts including tumors, susceptibility to parasites, skin lesions and genetic alterations. It is possible that, given the proximity of the ARCO site to the Tappan Terminal Site, both sites could experience these problems due to the affinity of the contaminants involved for binding to fine organic material which would deposit in the dredged locations. Location-specific faunal sampling may be needed to determine if epibenthic and benthic organisms are stressed. Manifestations of sublethal effects in the higher food chain organisms is not likely to pinpoint a problem in this location because of the large home range over which these organisms feed.

1.4 Remedial Action Objectives

Remedial action objectives are goals developed for the protection of human health and the environment. Definition of these objectives requires an assessment of the contaminants and media of concern, migration pathways, exposure routes and potential receptors. Typically, remediation goals are established based upon standards, criteria and guidelines to protect human health and the environment. SCGs for the Tappan Terminal Site, which were developed as part of the remedial investigation, include NYSDEC Recommended Soil Cleanup Objectives and New York Class GA Groundwater Standards and Guidance Values. Based on these SCGs and the results of the remedial investigation, the remedial action objectives developed for the Tappan Terminal Site are the following:

- Protect public health and the environment;
- Prevent direct contact exposure (dermal absorption, inhalation and incidental ingestion) with contaminated soil;
- Prevent precipitation from infiltrating through contaminated soil and adversely impacting groundwater; and
- Reduce contaminant levels to below groundwater standards and prevent further migration of contaminated groundwater off-site to Hudson River.

In addition to consideration of SCGs to meet the remedial action objectives, applicable or relevant and appropriate requirements (ARARs) are to be considered when formulating, screening and evaluating remedial alternatives, and selecting a remedial action. ARARs may be categorized as

Table 1-5 (continued)

POTENTIALLY APPLICABLE ACTION SPECIFIC ARARs/TBCs
TAPPAN TERMINAL SITE

Citation/ Reference	Title	Applicable Media	Potential ARAR/TBC	Regulatory Agency
Air Guide No. 29	Technical Guidance for Regulating and Permitting Air Emissions from Air Strippers, Soil Vapor Extraction Systems and Cold-Mix Asphalt Units	Air	TBC	NYSDEC
Air Guide No. 41	Permitting for Landfill Gas Energy Recovery	Air	TBC	NYSDEC
TAGM HWR-4030	Selection of Remedial Actions at Inactive Hazardous Waste Disposal Sites	Hazardous Waste	TBC	NYSDEC
TAGM HWR-4031	Fugitive Dust Suppression and Particulate Monitoring Programs at Inactive Hazardous Waste Sites	Air	TBC	NYSDEC
TAGM HWR-4046	Determination of Soil Cleanup Objectives and Cleanup Levels	Soil	TBC	NYSDEC
N/A	Analytical Services Protocol	All Media	TBC	NYSDEC
TOGS 1.3.1	Waste Assimilative Capacity Analysis & Allocation for Setting Water Quality Based Effluent Limits	Wastewater Discharge	TBC	NYSDEC
TOGS 1.3.1C	Development of Water Quality Based Effluent Limits for Metals Amendment	Wastewater Discharge	TBC	NYSDEC
TOGS 1.3.4	BPJ Methodologies	Wastewater Discharge	TBC	NYSDEC
TOGS 2.1.2	UIR at Groundwater Remediation Sites	Groundwater	TBC	NYSDEC
TOGS 2.1.3	Primary & Principal Aquifer Determinations	Groundwater	TBC	NYSDEC
29 CFR 1910.120	Hazardous Waste Operations and Emergency Response	NA	ARAR	USDOL
40 CFR 122	EPA Administered Permit Programs: The National Pollutant Discharge Elimination System	Wastewater Discharge	ARAR	USEPA

Cost evaluations presented in this document estimate the capital, and operation and maintenance (O&M) costs, including monitoring, associated with each remedial action alternative. From these estimates, a total present worth for each option is determined.

Community acceptance evaluates the technical and administrative issues and concerns which the community may have regarding each of the alternatives.

1.6 Feasibility Study Approach

In this feasibility study technologies are organized, identified and screened by media as follows: surface and subsurface soil and groundwater.

Results of the remedial investigation and risk assessment indicate that both surface and subsurface soil contamination will pose a threat to human health as it pertains to future use of the property. The site consists of two parcels, the Uhlich property and the Mobil property, and each may be used differently in the future.

Since it is likely that the Uhlich property will continue to be utilized as an industrial property, remediation of the contamination at this site will consider future site use for non-residential purposes. Similarly, since the Mobil property is now vacant, and future use can range from industrial to residential, remediation of this property will focus on remediation to future site use for both residential and non-residential purposes.

Groundwater has been determined to be significantly contaminated on-site and is migrating towards the Hudson River. Therefore, remediation of groundwater will be evaluated as part of the feasibility study.

impacts including tumors, susceptibility to parasites, skin lesions and genetic alterations. It is possible that, given the proximity of the ARCO site to the Tappan Terminal Site, both sites could experience these problems due to the affinity of the contaminants involved for binding to fine organic material which would deposit in the dredged locations. Location-specific faunal sampling may be needed to determine if epibenthic and benthic organisms are stressed. Manifestations of sublethal effects in the higher food chain organisms is not likely to pinpoint a problem in this location because of the large home range over which these organisms feed.

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In addition to consideration of SCGs to meet the remedial action objectives, applicable or relevant and appropriate requirements (ARARs) are to be considered when formulating, screening and evaluating remedial alternatives, and selecting a remedial action. ARARs may be categorized as contaminant-specific, location-specific or action-specific. Federal statutes, regulations and programs may apply to the site where state or county standards do not exist. Potentially applicable contaminant-specific, location-specific and action-specific ARARs for the Tappan Terminal Site, along with guidance, advisories, criteria, memoranda and other information issued by regulatory agencies to be considered (TBC), are presented in Tables 1-3, 1-4 and 1-5. As a note, many of the NYSDEC ARARs include federal requirements which have been delegated to New York State. Generally, federal ARARs are referenced when state requirements do not exist.

1.5 Feasibility Study Description

The Technical and Administrative Guidance Memorandum (TAGM) prepared by NYSDEC entitled, "Selection of Remedial Actions at Inactive Hazardous Waste Sites," describes the feasibility study as a process to identify and screen potentially applicable remedial technologies, combine technologies into alternatives and evaluate appropriate alternatives in detail, and select an appropriate remedial action plan. The objective of this feasibility study is to meet the goal of this guidance document as well as USEPA guidance in a focused, concise manner.

The approach of a feasibility study is to initially develop remedial action objectives for medium-specific or operable unit-specific goals to protect human health and the environment. The goals consider the contaminants and contaminant concentrations as determined by the remedial investigation, the exposure routes and potential receptors as determined by the baseline risk assessment, and the acceptable contaminant or risk levels or range of levels.

In the initial phase of the feasibility study, identified remedial technologies which are not technically applicable to contamination found, or are unproven and/or are not commercially available, will be eliminated from further consideration. The technologies remaining after initial screening may be assembled into remedial alternatives for evaluation. Preliminary evaluation of alternatives will consider effectiveness, implementability and relative costs.

Table 1-3

POTENTIALLY APPLICABLE CHEMICAL SPECIFIC ARARs/TBCs
TAPPAN TERMINAL SITE

Citation/ Reference	Title	Applicable Media	Potential ARAR/TBC	Regulatory Agency
6 NYCRR 212	General Process Emission Sources	Air	ARAR	NYSDEC
6 NYCRR 257	Air Quality Standards	Air	ARAR	NYSDEC
6 NYCRR 371	Identification and Listing of Hazardous Waste	Hazardous Waste	ARAR	NYSDEC
6 NYCRR 376	Land Disposal Restrictions	Hazardous Waste	ARAR	NYSDEC
6 NYCRR 700-705	Surface Water and Groundwater Classifications and Standards	Surface Water/ Groundwater	ARAR	NYSDEC
6 NYCRR 750-758	State Pollutant Discharge Elimination System	Wastewater Discharge	ARAR	NYSDEC
State Sanitary Code - Part 5	Drinking Water Supply	Water Supply	ARAR	NYSDOH
TOGS 1.1.1	Ambient Water Quality Standards and Guidance Values	Surface Water/ Groundwater	TBC	NYSDEC
TOGS 1.3.1	Waste Assimilative Capacity Analysis & Allocation for Setting Water Quality Based Effluent Limits	Wastewater Discharge	TBC	NYSDEC
TOGS 1.3.1C	Development of Water Quality Based Effluent Limits for Metals Amendment	Wastewater Discharge	TBC	NYSDEC
TOGS 1.3.2	Toxicity Testing in the SPDES Program	Wastewater Discharge	TBC	NYSDEC
Air Guide No. 1	Guideline for the Control of Toxic Ambient Air Contaminants	Air	TBC	NYSDEC
TAGM HWR-4046	Determination of Soil Cleanup Objectives and Cleanup Levels	Soil	TBC	NYSDEC

Table 1-4

POTENTIALLY APPLICABLE LOCATION SPECIFIC ARARs/TBCs
TAPPAN TERMINAL SITE

Citation/ Reference	Title	Applicable Media	Potential ARAR/TBC	Regulatory Agency
6 NYCRR 256	Air Quality Classification System	Air	ARAR	NYSDEC
N/A	Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Sites	Hazardous Waste Sites	TBC	NYSDEC

Table 1-5

POTENTIALLY APPLICABLE ACTION SPECIFIC ARARs/TBCs
TAPPAN TERMINAL SITE

Citation/ Reference	Title	Applicable Media	Potential ARAR/TBC	Regulatory Agency
6 NYCRR 200	General Provision	Air	ARAR	NYSDEC
6 NYCRR 201	Permits and Registrations	Air	ARAR	NYSDEC
6 NYCRR 211	General Prohibitions	Air	ARAR	NYSDEC
6 NYCRR 212	General Process Emission Sources	Air	ARAR	NYSDEC
6 NYCRR 364	Waste Transporter Permits	Solid/Hazardous Waste	ARAR	NYSDEC
6 NYCRR 370	Hazardous Waste Management System – General	Hazardous Waste	ARAR	NYSDEC
6 NYCRR 372	Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities	Hazardous Waste	ARAR	NYSDEC
6 NYCRR 373	Hazardous Waste Management Facilities	Hazardous Waste	ARAR	NYSDEC
6 NYCRR 375	Inactive Hazardous Waste Disposal Site Remedial Program	Hazardous Waste	ARAR	NYSDEC
6 NYCRR 376	Land Disposal Restrictions	Hazardous Waste	ARAR	NYSDEC
6 NYCRR 617 and 618	State Environmental Quality Review	All Media	ARAR	NYSDEC
6 NYCRR 621	Uniform Procedures	All Media	ARAR	NYSDEC
6 NYCRR 624	Permit Hearing Procedures	All Media	ARAR	NYSDEC
6 NYCRR 650	Qualifications of Operators of Wastewater Treatment Plants	NA	ARAR	NYSDEC
6 NYCRR 700-705	Classifications and Standards of Quality and Purity	Surface Water/ Groundwater	ARAR	NYSDEC
6 NYCRR 750-758	State Pollutant Discharge Elimination System	Surface Water/ Groundwater	ARAR	NYSDEC
Air Guide No. 1	Guideline for the Control of Toxic Ambient Air Contaminants	Air	TBC	NYSDEC

Table 1-5 (continued)

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40 CFR 122	EPA Administered Permit Programs: The National Pollutant Discharge Elimination System	Wastewater Discharge	ARAR	USEPA

Effectiveness evaluation includes consideration of the following:

- The potential effectiveness of process options in handling the estimated areas or volumes of contaminated media, and meeting the remediation goals identified by the remedial action objectives;
- The potential impacts to human health and the environment during the construction and implementation phase; and
- The proven effectiveness and reliability of the process with respect to the contaminants and conditions at the site.

Implementability includes both the technical and administrative feasibility of utilizing the technology or alternative. Administrative feasibility considers institutional factors such as the ability to obtain necessary permits for on-site or off-site actions, and the ability to restrict land use based on specific remediation measures. Technical feasibility considers such aspects as the ability to comply with SCGs, the availability and capacity of treatment, storage and disposal facilities, the availability of equipment and skilled labor to implement the technology, the ability to design, construct and operate the alternative, and acceptability to the regulatory agencies and the public.

Preliminary costs are considered at this stage of the feasibility study process for the purpose of relative cost comparison among the alternatives.

The results of the preliminary evaluation includes potentially viable technologies or combinations of technologies/alternatives for the site which will be carried forward for detailed evaluation.

The guidance requires that a feasibility study provide a detailed analysis of the potential remedial alternatives based on consideration of the following evaluation criteria for each alternative.

- Threshold Criteria
  - Compliance with applicable regulatory standards, criteria and guidelines
  - Protection of human health and the environment

- Balancing Criteria
  - Short-term impacts and effectiveness
  - Long-term effectiveness and permanence
  - Reduction in toxicity, mobility and/or volume of contamination
  - Implementability
  - Cost

In addition to the above listed Threshold and Balancing Criteria, the guidance also provides the following modifying criteria:

- Modifying Criteria
  - Community acceptance

Provided below is a description of each of the feasibility study criteria.

Compliance with applicable regulatory standards, criteria and guideline applies the federal and New York State ARARS/SCGs identified for the Tappan Terminal Site to provide both action-specific guidelines for remedial work at the site and contaminant-specific cleanup standards for the alternatives under evaluation. In addition to action-specific and contaminant-specific guidelines, there are also location-specific guidelines that pertain to such issues as restrictions on actions at historic sites. These guidelines and standards are referenced in Section 1.4 of this document and are considered a minimum performance specification for each remedial action alternative under consideration.

Protection of human health and the environment is evaluated on the basis of estimated reductions in both human and environmental exposure to contaminants for each remedial action alternative. The evaluation focuses on whether a specific alternative achieves adequate protection, and how site risks are eliminated, reduced or controlled through treatment, engineering or institutional controls. An integral part of this evaluation is an assessment of long-term residual risks to be expected after remediation has been completed. Evaluation of the human health and environmental protection factor is generally based, in part, on the findings of a risk or exposure assessment. The risk assessment performed for this site incorporates the quantitative estimation of the risk posed by carcinogenic and noncarcinogenic contaminants detected during the remedial investigation.

Evaluation of short-term impacts and effectiveness of each alternative examines health and environmental risks likely to exist during the implementation of a particular remedial action. Principal factors for consideration include the expediency with which a particular alternative can be completed, potential impacts on the nearby community and on-site workers, and mitigation measures for short-term risks required by a given alternative during the necessary implementation period.

Examination of long-term impacts and effectiveness for each alternative requires an estimation of the degree of permanence afforded by each alternative. To this end, the anticipated service life of each alternative must be estimated, together with the estimated quantity and characterization of residual contamination remaining on-site at the end of this service life. The magnitude of residual risks must also be considered in terms of the amount and concentrations of contaminants remaining following implementation of a remedial action, considering the persistence, toxicity and mobility of these contaminants, and their propensity to bioaccumulate.

Reduction in toxicity, mobility and volume of contaminants is evaluated on the basis of the estimated quantity of contamination treated or destroyed, together with the estimated quantity of waste materials produced by the treatment process itself. Furthermore, this evaluation considers whether a particular alternative will achieve the irreversible destruction of contaminants, treatment of the contaminants or merely removal of contaminants for disposal elsewhere.

Evaluation of implementability examines the difficulty associated with the installation and/or operation of each alternative on-site and the proven or perceived reliability with which an alternative can achieve system performance goals (primarily the SCGs discussed above). The evaluation must examine the potential need for future remedial action, the level of oversight required by regulatory agencies, the availability of certain technology resources required by each alternative and community acceptance of the alternative.

Cost evaluations presented in this document estimate the capital, and operation and maintenance (O&M) costs, including monitoring, associated with each remedial action alternative. From these estimates, a total present worth for each option is determined.

Community acceptance evaluates the technical and administrative issues and concerns which the community may have regarding each of the alternatives.

1.6 Feasibility Study Approach

In this feasibility study technologies are organized, identified and screened by media as follows: surface and subsurface soil and groundwater.

Results of the remedial investigation and risk assessment indicate that both surface and subsurface soil contamination will pose a threat to human health as it pertains to future use of the property. The site consists of two parcels, the Uhlich property and the Mobil property, and each may be used differently in the future.

Since it is likely that the Uhlich property will continue to be utilized as an industrial property, remediation of the contamination at this site will consider future site use for non-residential purposes. Similarly, since the Mobil property is now vacant, and future use can range from industrial to residential, remediation of this property will focus on remediation to future site use for both residential and non-residential purposes.

Groundwater has been determined to be significantly contaminated on-site and is migrating towards the Hudson River. Therefore, remediation of groundwater will be evaluated as part of the feasibility study.

Section 2

2.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

2.1 Introduction

In general, response actions which satisfy remedial objectives for a site include institutional, containment, isolation, removal or treatment actions. In addition, United States Environmental Protection Agency guidance under the Comprehensive Emergency Response, Compensation and Liability Act requires the evaluation and comparison of a no-action alternative to the action alternatives. Each response action for each medium of interest must satisfy the remedial action objectives for the site or the specific area of concern. Technologies and process options, which are available commercially and have been demonstrated successfully, are identified in this feasibility study along with certain selected emerging technologies. The screening of process options or technology types is performed by evaluating the ability of each technology to meet specific remedial action objectives, technical implementability, and short-term and long-term effectiveness. A discussion of selected response actions and their applicability to the Tappan Terminal Site is provided below. Preliminary evaluation/screening of the response action and remedial technologies will be based on technical effectiveness as it relates to the site-specific characteristics of the site. However, where appropriate, consideration will also be given to implementability and cost.

2.2 No Action

The no-action alternative will be considered, and as described above, will serve as a baseline to compare and evaluate the effectiveness of other actions. Under the no-action scenario, limited remedial response actions may be considered including monitoring. Monitoring would consist of periodic groundwater sampling to evaluate changes over time in conditions at the site and to ascertain the level of any natural attenuation which may occur or any increase in contamination which may necessitate further remedial action. Natural attenuation (under the no-action alternative), as opposed to active remediation, relies on naturally occurring physical, chemical and biological processes (dilution, dispersion and degradation) to reduce contaminant concentrations.

2.3 Institutional Controls

Institutional controls may include site access restrictions, such as placement of fencing around the areas of concerns, posting of signs warning the public of the presence of contamination and deed restrictions. Deed restrictions could be imposed to limit uses of and activities at the site. Current zoning for industrial use is an institutional control to limit site use and activities. Deed restrictions, in addition to zoning, which prohibit/restrict future use and development, would also be a potentially applicable alternative for the site.

Other institutional controls may include groundwater use restrictions to ensure groundwater is not utilized.

2.4 Groundwater Remediation Technologies

Treatment, collection and containment technologies, which could be applicable to remediation of groundwater contaminated with volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides and metals are identified and evaluated below. As discussed in Section 1.0, although the primary contaminant at the site is chlorobenzene, levels of SVOCs, pesticides and metals may also require treatment in order to meet discharge requirements or in order to eliminate potential problems, such as iron precipitation, during treatment of VOCs.

2.4.1 Extraction and Treatment

Extraction and treatment or "pump and treat" technologies are widely used for groundwater remediation and/or containment.

2.4.1.1 - Extraction Technologies

Extraction is a remedial technology generally used in combination with treatment technologies to control and remove contaminants in groundwater. Two extraction technologies, pumping wells and groundwater interceptor trenches, are described below.

2.4.1.1.1 - Wells

Technology Description: The use of wells to pump contaminated groundwater to the surface for treatment is widely used as a remedial technology. With this technology, contaminated groundwater can be extracted for on-site or off-site treatment and disposal. Groundwater modeling and/or pump tests are generally utilized to determine optimal pumping rates and well locations.

Initial Screening Results: Extraction wells represent a potentially viable technology for remediation of groundwater at the Tappan Terminal Site. Therefore, this technology will be retained for further evaluation.

2.4.1.1.2 - Interceptor Trenches

Technology Description: As opposed to wells, which can extract shallow and deep contaminated groundwater, interceptor trenches have been used successfully to extract groundwater in situations where the depth to groundwater is shallow, contamination is limited to the upper portion of the aquifer and soils can be excavated without causing structural damage and interfering with underground utilities.

Initial Screening Results: Due to the shallow depth to groundwater contamination at the site and the absence of active structures and utilities on the Mobil property, the use of groundwater interceptor trenches will be retained for further evaluation.

2.4.1.2 - Ex-situ Treatment Technologies

Once extracted, contaminated groundwater must be treated to meet discharge standards. Treatment technologies include biological, chemical and physical processes. A number of these technologies are described below.

2.4.1.2.1 - Air Stripping

Technology Description: Air stripping involves a process by which volatile organic compounds and some semivolatile organic compounds are partitioned from groundwater by greatly increasing the surface area of the contaminated water exposed to air. Types of aeration methods include packed towers, diffused aeration, tray aeration and spray aeration. Air stripping is a widely used, proven and commercially available technology.

The applicability and effectiveness of air stripping depends on the potential for inorganic or biological fouling of the equipment. Clogging of the stripping column packing material due to inorganics in the groundwater (especially dissolved ferrous iron, which precipitates out as insoluble ferrous hydroxide species upon aeration) and biofouling (iron bacteria) are common problems if not taken into consideration during design. In addition, the Henry's Law constant of the organic compounds in the water stream will determine the effectiveness of air stripping.

Initial Screening Results: Air stripping represents a potentially viable technology for treatment of extracted groundwater at the Tappan Terminal Site. Therefore, this technology will be retained for further evaluation.

2.4.1.2.2 - Carbon Adsorption (Liquid Phase)

Technology Description: Carbon adsorption involves a process by which groundwater is pumped through canisters containing activated carbon to which dissolved contaminants adsorb. The technology requires periodic replacement or regeneration of saturated carbon. Carbon adsorption (liquid phase) is a widely used, proven and commercially available technology. The applicability and effectiveness of carbon adsorption may be limited by the presence of certain compounds which can foul the system, high contaminant concentration levels and the physical properties of the contaminants, among other factors.

Initial Screening Results: Carbon adsorption is effective in the removal of VOCs, SVOCs and pesticides from the contaminated groundwater on-site. Therefore, this technology will be retained for further evaluation.

2.4.1.2.3 - Oxidation

Technology Description: Ultraviolet (UV) radiation, ozone and/or hydrogen peroxide may be used to destroy contaminants as groundwater flows into a treatment tank. An ozone destruction unit is used to treat off-gas from the treatment tank. UV oxidation is a commercially available technology which is effective in the treatment of volatile and semivolatile organic compounds.

Initial Screening Results: Oxidation is a potentially viable technology for treatment of extracted groundwater at the Tappan Terminal Site. Therefore, this technology will be retained for further evaluation.

2.4.1.2.4 - Biological Treatment

Technology Description: Typically, this technology involves the introduction of groundwater into biological treatment units where enzymes and microorganisms decompose organic contaminants into carbon dioxide, water and nonhazardous by-products. Supplemental nutrients may be added to assist the biological process. Biological treatment occurs at the rate of decomposition, which may be low. Biodegradation may also be accomplished in situ through the same biological processes.

Initial Screening Results: Biological treatment is generally less effective than available alternative technologies on chlorinated organic contaminants which are present in groundwater at the Tappan Terminal Site. Therefore, this technology will not be considered further.

2.4.1.2.5 - Reverse Osmosis

Technology Description: Osmosis is a process which occurs when two solutions of different solute concentrations reach an equilibrium across a semi-permeable membrane. The solvent (water in this case) will naturally flow from the less concentrated solution into the more concentrated solution. To reverse this process, the solution with the high concentrations must be pressurized to a level higher than the osmotic pressure. At sufficiently high pressures, usually 200 to 800 pounds per square inch (psi), the water will flow out of the more concentrated solution, leaving the contaminants trapped on the other side of the semi-permeable membrane. The volume of the concentrated waste is generally 10 to 20% of the feed volume. This concentrated waste will require additional treatment.

Reverse osmosis has been demonstrated to be effective for treatment of brackish waters, aqueous inorganic wastes and radionuclides, and recent findings indicate that it is useful in removing some specific organic compounds from solution. The effectiveness of this process is highly dependent on the chemical composition of the waste solution to be treated and the characteristics of the membrane.

Initial Screening Results: Since more effective and proven methods for treatment of volatile organic and inorganic contaminants are readily available and large volumes of reject water would be generated, reverse osmosis will not be considered further.

2.4.1.2.6 - Filtration

Technology Description: Filtration is a process in which suspended and colloidal particles, which are not readily settleable, are removed from water by physical entrapment on a media. Fluid flow through the filter media may be accomplished by gravity or it may be pressure induced. Beds of granular material, such as sand and anthracite, are commonly used filters in groundwater treatment. Other types of filters include vacuum filters, plate and frame filters, and belt filters. These are often used to dewater sludges produced by processes like sedimentation and chemical precipitation. Packed beds of granular material are usually backwashed to remove the filter cake.

The collected solids will require disposal and costs will depend on whether the material is hazardous or nonhazardous.

Initial Screening Results: Filtration is used to remove suspended solids and colloidal particles as part of a water treatment process, and therefore, will be retained for further consideration as part of an overall treatment process for extracted groundwater.

2.4.1.2.7 - Ion Exchange

Technology Description: Ion exchange is a process in which ions are removed from solution by exchange with non-toxic ions supplied by the ion exchange material. Inorganic compounds can be removed by this process. Generally, a train of resin beds in series containing different resins for cation and anion removal are used. The beds must be monitored for breakthrough and must be regenerated using a wide variety of regeneration chemicals which may themselves be hazardous. Ion exchange can be used both as a pretreatment and as a polishing step.

Initial Screening Results: Ion exchange may be suitable for the removal of inorganic compounds from extracted groundwater as part of an overall groundwater treatment process. Therefore, this technology will be retained for further consideration.

2.4.1.2.8 - Chemical Precipitation and Clarification

Technology Description: Precipitation is a physical and chemical technique that can be used to remove metals from an aqueous stream. The metals can be precipitated out of solution by changing the chemical equilibrium of the solution. This is generally achieved by adding a chemical that reacts directly with the contaminant to form an insoluble settleable product. When used prior to other treatment technologies, this process eliminates the probability of reduced efficiency due to dissolved metals precipitation during later phases of treatment. The pH can be adjusted to optimize the precipitation process. Metals can be precipitated as hydroxides, carbonates and sulfides. Typical precipitating agents include calcium oxide, caustic soda, sodium sulfide, ferrous sulfide and hydrogen sulfide gas.

Initial Screening Results: Chemical precipitation may be utilized for the removal of inorganics as part of an overall groundwater treatment process. Therefore, this technology will be retained for further consideration.

2.4.1.3 - Discharge Options

Groundwater extraction and treatment systems will generate a treated wastewater requiring proper management and disposal. Several discharge management options are identified below.

2.4.1.3.1 - Publicly Owned Treatment Works

Option Description: Under this option, treated, pretreated or untreated discharge would be routed to the nearest sewer system. The effluent would have to meet the discharge requirements of the publicly owned treatment works (POTW). With regard to the Tappan Terminal Site site, the POTW is the Yonkers Wastewater Treatment facility.

Initial Screening Results: Discharge to the sewer system represents a potentially viable option for disposal of treated groundwater assuming the POTW requirements can be met. Upon preliminary conversations with Westchester County Department of Environmental Facilities, they indicated that they would accept wastewater at a maximum discharge rate of 15 gpm. Since it is likely that higher volumes of groundwater will need to be extracted to meet remediation goals, this option will not be considered further.

2.4.1.3.2 - Off-site Transportation and Disposal of Treated Groundwater

Option Description: This option involves on-site storage and subsequent transport and off-site disposal of treated groundwater.

Initial Screening Results: Due to the excessive storage and handling requirements associated with the large volumes of extracted water anticipated, this option will not be considered further.

2.4.1.3.3 - Surface Water

Option Description: Discharge to surface water would entail meeting the substantive requirements of a State Pollution Discharge Elimination System (SPDES) permit which would require treatment to standards for discharge to the Hudson River, along with routine monitoring of the discharge. In addition, construction of pipe would be required to convey the treated discharge to the receiving surface water.

Initial Screening: This option will be retained for further evaluation which would include evaluation for meeting all of the requirements of a SPDES permit.

2.4.1.3.4 - On-Site Recharge/Reinjection

Option Description: Recharge/reinjection options include discharge of treated groundwater to a recharge basin, injection wells or leaching pools. Again, the substantive requirements of a SPDES permit would need to be met. This option if implemented on or near the site would have to be evaluated with respect to potential impact on the groundwater extraction strategy being implemented.

Initial Screening: Since the depth to groundwater on site is shallow (2 to 7 feet), recharge basins and leaching pools would not be effective in recharging treated groundwater. In addition, injection wells are prone to clogging and require a high degree of maintenance. Due to the availability of more viable options for discharge of treated groundwater at the Tappan Terminal Site, on-site recharge/reinjection will not be considered further.

2.4.2 In-Situ Treatment

In-situ treatment technologies for remediation of groundwater involve both proven and "emerging" techniques, as described below.

2.4.2.1 - In-Well Air Stripping

Technology Description: In-well air stripping is a process by which air is injected into a well, lifting contaminated groundwater in the well and allowing additional groundwater flow into the well. Once inside the well, the volatile organic compounds in the contaminated groundwater are transferred from the water to air bubbles which rise and are collected at the top of the well by vapor extraction. The treated groundwater is not brought to the surface, but rather, it is forced into the saturated or unsaturated zone, and the process is repeated. As groundwater circulates through the treatment system in situ, contaminant concentrations are reduced. The flow rate and well spacing may be varied in order to achieve the desired radius of influence and capture zone. Detailed characterization of the geology/hydrogeology of the site is required to ensure the wells provide appropriate groundwater recirculation. The effectiveness of in-well air stripping may be impacted by the presence of clay and silt lens, subsurface utilities and structures. These subsurface anomolies could interfere with circulation and could create short circuiting of the system. In addition, the shallow depth of the aquifer at the site, approximately 10 feet, would make it difficult to construct an appropriate groundwater recirculation cell. As discussed with ex-situ air stripping, elevated levels of iron could cause problems with clogging of the well screen. Although in-well air stripping is a developing technology, it is commercially available.

Initial Screening Results: Due to concerns regarding clogging of the screens with iron precipitate and iron bacteria and potential difficulties in obtaining adequate treatment utilizing groundwater recirculation due to the shallow depth of aquifer, in-well air stripping will not be retained for further consideration.

2.4.2.2 - Air Sparging

Technology Description: Air sparging involves injecting air into a saturated matrix in order to create an underground VOC stripping mechanism that removes contaminants through volatilization. The technology is designed to operate at sufficient air flow rates in order to effect volatilization. At lower air flow rates the system is used to increase groundwater oxygen concentrations to stimulate biodegradation. Air sparging must operate in conjunction with a soil vapor extraction (SVE) system that captures volatile contaminants in the unsaturated zone as they are stripped from the saturated zone. Wells must be appropriately placed to overlap the radius of influence for each well and effectively remediate the contaminated zone. Low permeability soils may not allow adequate air flow. Air sparging is generally applicable to shallow groundwater contamination so that the released vapors can be adequately captured. It is also applicable to fairly permeable soils.

The fill unit at the site is defined as sand and silt size particles with some gravel which should be amenable to air sparging. In addition, the depth of contaminated groundwater is shallow. The shallow depth to water can cause extraction of water into the vapor extraction system and generation of large quantities of contaminated condensate which may be problematic. Treatment for the extracted water would likely be necessary. Air sparging is a widely used, proven, commercially available technology; however, the applicability and effectiveness of the process is limited by the depth of contamination and geology.

Initial Screening Results: Due to the permeable fill material and the shallow depth of groundwater contamination, air sparging will be considered further.

2.4.2.3 - Bioremediation/Oxygen Enhancement

Technology Description: Bioremediation with oxygen enhancement can be performed using various methods. One method involves injecting air under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of organic contaminants by naturally occurring microbes. The injection of air also increases mixing in the saturated zone, which increases the contact between groundwater and soil. The ease and low cost of installing small-diameter air injection points allows considerable flexibility in the design and construction of such a system.

A second method involves the use of a dilute solution of hydrogen peroxide which is circulated throughout a contaminated groundwater zone to increase the oxygen content of groundwater and enhance the rate of aerobic degradation of organic contaminants by naturally occurring microbes. For best results, factors that must be considered include redox conditions, saturation rates, presence of nutrient trace elements, pH, temperature and permeability of the subsurface materials. Groundwater contaminated by fuel related products has been shown to degrade rapidly under aerobic conditions, but success is often limited by the inability to provide sufficient oxygen to the contaminated zones. Without a groundwater circulation system, partially degraded contaminants could migrate from the zones of active biodegradation.

Similar to the other in-situ remedial technologies discussed above, subsurface anomalies, such as clay/silt lens, utilities and structures can impact the effective distribution of oxygen in the subsurface. The applicability and effectiveness of the process may also be limited by the potential for migration of vapors through the vadose zone and release into the atmosphere or subsurface structures due to the introduction of oxygen into groundwater and lack of vapor controls in the overlying vadose zone. Bioremediation/oxygen enhancement is generally a long-term technology to remediate a plume of contaminated groundwater. Bioremediation with oxygen enhancement is a full-scale commercially available technology.

Initial Screening Results: Due to the potential problems with oxygen delivery, migration of contaminants in groundwater from the zones of active biodegradation and migration of vapors in the vadose zone, this technology will not be retained for further consideration.

2.4.2.4 - Dual Phase Extraction

Technology Description: Dual phase extraction technologies involve applying a high vacuum system to simultaneously remove liquid (groundwater) and gas (volatile vapors) from low permeability or heterogeneous formations. The vacuum extraction well includes a screened section in the zone of contaminated soils and groundwater. As the vacuum is applied to the well, soil vapor is extracted and groundwater is entrained by the extracted vapors. Groundwater recovery is enhanced through the increased pressure gradient. Groundwater can also be recovered by pumping at or below the water table. Once above grade, the extracted vapors and groundwater are separated and treated through technologies described in Section 2.4.1. Dual-phase extraction is applicable to treatment of VOCs in subsurface soil and to all contaminants in groundwater since it would be treated ex situ. It would, however, require significant treatment equipment since it would be treating both extracted vapor and groundwater. Dual-phase extraction is a full-scale, commercially available technology.

Initial Screening Results: Although dual-phase extraction may be applicable to the groundwater and soil contamination located along the sewer line, it does not provide any additional benefit over soil vapor extraction and groundwater extraction and treatment. Therefore this technology will not be considered further.

2.4.2.5 - Chemical Oxidation

Technology Description: Chemical oxidation involves the use of an oxidant to treat or destroy organic contaminants in groundwater. Various types of oxidants that have been used include; hydrogen peroxide, permanganate and ozone. The following provides a brief description of each oxidant and its use.

Hydrogen peroxide is typically used in conjunction with ferrous iron to produce hydroxyl radicals which can attack the carbon-hydrogen bonds of organic molecules allowing this reaction to degrade chlorinated solvents, polyaromatic hydrocarbons and petroleum products. Since it is a destruction process, there is no potential for intermediate chlorinated, potentially more toxic compounds to be produced. Some of the disadvantages of the use of hydrogen peroxide is the hazardous nature of handling hydrogen peroxide, the potential for reduction of permeability of the soil due to formation of particulates during the reaction, and difficulties with delivery of the hydrogen peroxide to the contaminated zone since it can easily breakdown to water vapor and oxygen. The reaction is exothermic and can cause the release of off-gases and in some cases has been known to cause explosions.

Potassium permanganate can react with organic compounds to produce manganese dioxide and either carbon dioxide or intermediate organic compounds. Permanganate has been shown to oxidize organic compounds, such as alkenes, aromatics, PAHs, phenols, pesticides and organic acids. Permanganate is more stable that hydrogen peroxide and is easier to handle, however, there is a potential for permeability reduction due to the formation of particulates during the reaction.

Ozone is a very strong oxidant, reacts quickly in the subsurface and is difficult to deliver to the contaminated zone. Ozone must be generated on-site and can be used in a process similar to air sparging where it is injected in to the groundwater via wells. It has been shown to effectively treat chlorinated solvents, PAHs and petroleum products.

Several vendors are currently utilizing various forms of the above processes to treat contaminated groundwater. Therefore, although developing as a technology, it is commercially available.

Factors associated with the effective implementation of this process include detailed understanding of the nature and extent of contamination in order to effectively place the chemical oxidant. Subsurface anomalies, such as clay lens and underground utilities, can potentially short circuit the system if not adequately considered. The oxidants are also non-selective to both organic contaminants and natural organic matter. The presence of high natural organic matter content in the soils could consume a large portion of the added oxidants making treatment less economically feasible. Mounding of the groundwater from the injection of the oxidants is also a potential limitation. The process would not be effective in treating the elevated levels of metals at the site. Demonstration of the effectiveness of this technology to the contaminants of concern at the site would likely require a pilot study.

Initial Screening Results: Chemical oxidation represents a potentially viable technology for in-situ treatment of volatile and some semivolatile organic compounds. Therefore, this technology will be retained for further consideration.

2.4.2.6 - Reactive Walls

Technology Description: The use of passive treatment or reactive walls involves installing a permeable reaction wall across the flow path of a contaminant plume, allowing the plume to passively move through the wall. Typically, the contaminants are degraded by reactions with a mixture of porous media and a metal catalyst. The use of passive treatment walls is an emerging technology which is applicable only in relatively shallow aquifers, because a trench must be constructed down to the level of the bedrock or a low permeability geologic unit in order to install the reactive wall. In addition, passive treatment walls are often only effective for a short time, because they lose their reactive capacity, requiring replacement of the reactive medium.

Initial Screening Results: Due to the significant tidal influence on-site, which causes reverse in groundwater flow on the western edge of the site during high tide, reactive walls will not be considered further.

2.4.2.7 - Funnel and Gate

Technology Description: Another passive groundwater remediation technology, that is very similar to and incorporates the treatment/reactive wall technology, is the funnel-and-gate system. Like treatment walls, the funnel-and-gate system includes the installation of a permeable wall containing a mixture of porous media and treatment media which degrade the contaminants in groundwater and allow the treatment water to passively move through the wall. However, the primary difference between the two technologies is that the funnel-and-gate system includes the installation of low permeability or impermeable cut-off walls (or "funnels") such as slurry or sheet pile walls in the path of the contaminated groundwater or plume which direct or "funnel" the contaminated groundwater to a treatment/reactive wall (or "gate"). The "gate" passes the contaminated groundwater through the treatment wall, which then remediates the groundwater.

Advantages and disadvantages of the funnel and gate technology are similar to those of treatment walls. However, slurry walls, sheet piling and other materials that are used to form the funnel are often easier and/or more economical to install than the treatment walls. Therefore, construction of funnel and gate systems may be less costly than treatment wall systems depending upon the application.

Initial Screening Results: Similar to passive treatment walls, the movement of the contaminated groundwater through the containment walls would be impacted by the tidal influence and effectiveness reduced. Therefore, the funnel and gate system will not be considered further.

2.4.2.8 - Chemical Reduction

Technology Description: Injection of zero-valent colloidal iron to the subsurface through injection wells is developing as a practical alternative to installation of a passive treatment wall for the remediation of contaminated groundwater. Iron powder in a liquid slurry form is injected under pressure along with a nitrogen gas stream. When the iron comes in contact with water hydrogen gas, hydroxyl ions and ferrous iron are formed. The hydrogen gas then combines with the organic compound which is then dehalogenated. End products of the reaction are ferrous iron, chloride ions and the dehalogenated compounds. Injection wells can be installed much deeper than walls and can also, through the use of nano-meter colloids, generate a larger reactive surface area and thus more efficient use of iron.

Difficulties with effective injection of the iron to the contaminated areas with low permeability soils, such as silt and clays, can be enhanced through the use of pneumatic fracturing. Factors impacting the effectiveness of the process include appropriate placement of the iron and placement of sufficient amount of iron to react with contaminants of concern. In addition, large quantities of the injected iron can reduce the permeability of the soils and contact with the contaminants. Although in-situ chemical reduction it is an emerging technology, it is commercially available.

Initial Screening Results: Due to the potential applicability to the VOC contamination at the site, the limited disruption to the surface and limited interference by tidal influences, this technology will be considered further.

2.4.3 Containment Barriers

Containment barriers include subsurface structures such as vertically excavated trenches that are filled with a slurry or grout, sheet pile walls and adaptations of sheet pile walls with interlocking sealable joints. The following describes some of the different types of barriers that could be considered for the site.

2.4.3.1 - Slurry Walls

Technology Description: Slurry walls are typically constructed through excavation of soil to a desired depth, generally into a low permeability material such as clay or bedrock, and placement of a bentonite water slurry to maintain trench stability. Soil-bentonite backfill is placed in the slurry to form the soil-bentonite slurry trench cutoff wall. Cement can also be used in the slurry. Slurry walls can be constructed up to depths of 200 feet, and depending upon the mixture of soil, bentonite and cement walls can have hydraulic conductivities between 10^{-6} to 5×10^{-9} cm/sec. Disadvantages of a slurry wall include the volume of soil generated that would require disposal during installation of the wall and the potential for the wall to degrade or deteriorate over time due to contaminants in the soil or groundwater, or freeze/thaw cycles.

Initial Screening Results: Slurry walls are an applicable technology for the Tappan Terminal Site if combined with treatment technologies for groundwater remediation. Therefore, this technology will be considered further.

2.4.3.2 - Sheet Pile Walls

Technology Description: Sheet pile walls are constructed by driving vertical strips of steel, precast concrete, aluminum or wood into the soil forming a subsurface barrier wall. The sheets are assembled before installation and driven or vibrated into the ground a few feet at a time to the desired depth, generally into a low permeability unit. A continuous wall can be constructed by joining the sheets together. The joints between the sheet piles are vulnerable to leakage, and therefore, the hydraulic conductivities are generally higher than slurry walls.

Initial Screening Results: Due to the concerns with regard to leakage of the sheet pile walls and the availability of adaptations of sheet pile walls that address the problem of leaky joints at a comparable cost, sheet pile walls will not be considered further.

2.4.3.3 - Waterloo Barrier

Technology Description: As noted above, due to the problems with leakage in the joints of sheet pile walls, the Waterloo Barrier was developed in order to address the leakage of the joints. The Waterloo Barrier is designed to have interlocking sealable joints. The sheet piles are driven into the ground and the interlocking joint cavity is flushed to remove soil and debris and a clay based, cementitious, polymer or mechanical sealants are injected into the cavity. The barrier can achieve hydraulic conductivities of less than 10^{-8} cm/sec.

Initial Screening Results: The Waterloo Barrier is a commercially available technology that would be potentially applicable as a hydraulic barrier at the Tappan Terminal Site. Therefore, this technology will be considered further.

2.4.3.4 – Freeze Walls

Technology Description: Freeze walls or cryogenic barriers are constructed by artificially freezing soil pore water thereby decreasing the permeability of the soil and forming a low permeability barrier. Once the barrier is no longer needed, the cryogenic system can be turned off allowing the barrier to melt. A cryogenic wall is constructed through the placement of thermoprobes into the ground and circulating a refrigerant through them. Refrigerants such as liquid nitrogen, calcium chloride brine and carbon dioxide can be used. Laboratory tests have shown hydraulic conductivities as low as 4×10^{-10} cm/sec. Cryogenic walls are a developing technology and there is no long-term data available for full-scale wall efficiencies.

Initial Screening Results: Due to the fact that freeze walls are a developing technology, the costs for installation and maintenance of a full-scale barrier over the long term are uncertain, and the availability of other comparable, equally effective containment barriers, this technology will not be considered further.

2.5 Soil Remediation Technologies

2.5.1 Isolation/Containment

Potentially applicable isolation and containment technologies include surface barriers, such as permeable covers and low permeability caps. These technologies are designed to prevent direct contact with and migration of contaminants from the area of concern, and do not provide any treatment for contaminated soil. Various forms of surface barriers currently exist to significantly reduce the infiltration of precipitation into contaminated soil, and minimize surface runoff and contact with contaminated soil.

Low permeability caps have an advantage over permeable covers in that this technology would limit infiltration by precipitation in addition to mitigating direct contact with contaminated soil. However, low permeability caps are more costly, require a sloped surface to promote runoff and may preclude/limit the use of the capped area and require additional maintenance. The following is a discussion of various low permeability and permeable caps.

2.5.1.1 - RCRA Cap

Technology Description: This technology consists of constructing a cap over contaminated materials as defined in the Resource Conservation and Recovery Act (RCRA) Subpart N, 40 CFR 264.300.

A RCRA cap consists of three sections. The top section consists of a 2-foot vegetated topsoil and a soil layer. A geotextile is placed between the top section and middle section. The middle section contains a 1-foot sand and gravel filter which prevents clogging of the underlying drainage layer. The bottom section is a flexible membrane liner (FML) which overlies and protects a second low permeability 2-foot compacted soil/clay layer.

These caps are typically used for closure of landfills used for the disposal of hazardous wastes. The cap would prevent direct contact with contaminated soil, and would minimize infiltration of precipitation through contaminated soil and further contamination of groundwater. It would also eliminate contaminated runoff. The thickness (5 feet), maintenance requirements and slope (a minimum of 4%) of this type of cap would limit potential future land use options.

Initial Screening Results: A RCRA cap will provide significant protection from infiltration of precipitation into the contaminated subsurface and provides additional protection over other types of low permeability caps presented below. However, because of its very high cost, and other less costly caps being nearly as effective, this technology will not be retained for further consideration.

2.5.1.2 - Part 360 Cap

Technology Description: This technology consists of constructing a cap over waste materials as defined in 6 NYCRR Part 360. This cap consists of a four-layered system comprised, from top to bottom, of a vegetated topsoil upper layer, underlain by a drainage/barrier protection layer followed by a low permeability layer (10^{-7} cm/sec) comprised of clay (18 inches) or a flexible membrane liner (FML), followed by a gas venting layer. The thickness of the Part 360 cap with a FML is 2 to 3 feet. Similar to the RCRA cap described above, this cap also mitigates direct contact with contaminated soil, infiltration of precipitation and runoff of contaminants. The thickness, required maintenance and slope of the cap (minimum 4%) would also significantly reduce utilization of the capped area.

Initial Screening Results: A Part 360 of cap will provide significant protection from infiltration and although it may reduce utilization of the capped area it is thinner than the RCRA cap, and therefore, this technology will be considered further.

2.5.1.3 - Pavement Cap

Technology Description: An asphalt or concrete surface would significantly reduce the amount of infiltration into and contact with contaminated soil, as well as surface runoff of contaminants from the site. In addition, it could be implemented as part of site development, such as construction of buildings, roadways and parking areas. Drainage systems may need to be constructed to collect and direct surface runoff that currently infiltrates the area. This type of cover, which would be about 1 1/2 to 2 feet in thickness, would not be as thick as the RCRA cap (5 feet) or the Part 360 cap (2 to 3 feet), and the slope could be reduced to 2% to promote runoff. Maintenance would be required in order to ensure that cracks due to weathering, settlement or traffic are repaired.

Initial Screening Results: Since a pavement cap would limit infiltration of precipitation and contact with contaminated soil, and allow for development of the site, this technology will be considered further.

2.5.1.4 - Semi-permeable Cover

Technology Description: This technology provides for the placement of an 18-inch semi-permeable soil cover (10^{-5} cm/sec hydraulic conductivity). This type of cover would mitigate direct contact with contaminated soil and runoff of contaminated surface soil, but would not preclude infiltration of precipitation into contaminated soil.

Initial Screening Results: Since a semi-permeable cover will not provide any significant additional benefit over a permeable cover and will be more costly, this technology will not be considered further.

2.5.1.5 - Permeable Cover

Technology Description: This technology provides for the placement of a 2-foot soil ($>10^{-5}$ cm/sec hydraulic conductivity) or gravel/stone cover. This type of cover would mitigate direct contact with contaminated soil and runoff of contaminated surface soil, but will not mitigate infiltration of precipitation into contaminated soil.

Initial Screening Results: Although a permeable cover would not reduce infiltration of precipitation, it would provide protection against direct contact with and runoff of contaminated soil, and therefore, this technology will be considered further.

2.5.2 Soil Treatment

There are a number of demonstrated/commercially available technologies for the treatment of contaminated soil. Some treatment technologies can be performed in situ and other technologies require treatment of the soil ex situ. Ex-situ soil treatment processes would require excavation of the soil prior to treatment. Provided below is a discussion of a number of soil treatment technologies including bioremediation, solvent/acid extraction, soil washing, thermal separation/desorption and in-situ soil flushing.

2.5.2.1 - Solvent/Acid Extraction

Technology Description: The solvent/acid extraction process, as it applies to soil remediation, utilizes a solvent or an acid to extract organic/inorganic components from a solid matrix into a liquid solution. Physical separation steps are often used before extraction to grade the soil into coarse and fine fractions, with the assumption that the fines contain most of the contamination. The process typically utilizes a single vessel in which the solvent/acid is placed into contact with excavated soil. The solvent/acid is then recovered and recycled, and the extracted organic and/or inorganic contaminants are either disposed or recycled. The decontaminated soils can be backfilled on-site or landfilled depending on removal efficiencies of the process and/or land disposal restrictions. Extraction solvents/acids are not currently available for all contaminants and extraction efficiencies may vary for different types of soils and levels of contaminants.

One of the limitations of the solvent/acid extraction technology is that soils containing more than 20% moisture must be dried prior to treatment because excess water dilutes the solvent, reducing contaminant solubilization and transport efficiency. Due to the types of contaminants at the site, both solvent and acid extraction would be necessary to remove the organics and inorganics in the soil. Solvent/acid extraction would require excavation and extensive handling of the soils. Organically bound metals can be extracted with the organic contaminants which may preclude replacement of soils on-site after treatment without stabilization. Once removed and treated, there would still be the extracted residuals requiring additional treatment or off-site disposal.

Initial Screening Results: Solvent/acid extraction would likely not be applicable to treatment of all contaminants of concern at the site, would likely require significant handling of contaminated soils and have significant space requirements for the treatment process. Therefore, this technology will not be considered further.

2.5.2.2 - Soil Washing

Technology Description: Soil washing technologies physically separate soils so that the contaminants, which are primarily associated with the fine size fraction of the soil, are separated from the uncontaminated larger size fraction. The washing fluid may be composed of water and/or a surfactant capable of removing the contaminants from the soil. Either a solid-solid or liquid-solid separation is conducted where the contaminant can be leached by the fluid, or the contaminant is stripped from the particles with which it is associated. Soil would require excavation prior to treatment, and therefore, would have similar problems with regard to excavation and handling, as discussed above for solvent/acid extraction.

The products of the soil washing process are clean soil, wash water containing an oily phase, dissolved contaminants and/or precipitated solids, and a finer fraction containing adsorbed organics and precipitated soils. The result is high levels of contaminants concentrated into a relatively small volume of material, thereby simplifying the ultimate treatment or disposal of the contaminated media. Soil washing technologies can be effective for removing organics and inorganics from the soils depending on contaminant concentrations, soil characteristics and process capability.

Initial Screening Results: Contaminated surface and subsurface soil at the Tappan Terminal site has been characterized as a man made fill material composed of ash, slag, glass, metal debris, wood, crushed stone, coal, saw dust and brick fragments. Based upon the description of the fill material it is unlikely that soil washing will be effective in removing a contaminated material from the uncontaminated soil fraction. Due to the extensive soil handling required, the potential for a large volume of residual material requiring disposal and likely ineffectiveness of the process, soil washing will not be considered further.

2.5.2.3 - In-Situ Soil Washing (Soil Flushing)

In-situ soil washing is a process by which water or water containing a surfactant is applied to the unsaturated soil or injected into the groundwater to raise the water table into the contaminated soil zone. The process includes extraction of the groundwater and treatment/removal of the leached contaminants before the water/groundwater is recirculated. This technology has also been combined with the use of a cosolvent to extract organic contaminants.

Soil washing has been developed to treat nonhalogenated volatile organic compounds and inorganics. It may also be applicable to treat semivolatile organic compounds, fuels and pesticides. This technology is only applicable at sites in which flushed contaminants and soil flushing fluid can be contained and recaptured. Therefore, a low permeability boundary is generally required.

Limitations of soil flushing include the potential of washing the contaminant beyond the capture zone and concerns by regulators with the introduction of cosolvents into the subsurface. Aboveground separation and treatment costs for the recovered water and cosolvent can be costly. Soil flushing is still a developing technology and has been in limited use in the United States.

Initial Screening Results: Due to the potential for mobilization of contaminants, difficulties with separation and treatment of the flushing fluids, and limited use on a full-scale level, in-situ soil washing will not be considered further.

2.5.2.4 - Soil Vapor Extraction

Technology Description: Soil vapor extraction (SVE) is a remediation technology that utilizes a vacuum applied to extraction wells to remove volatile organic compounds from contaminated subsurface soil. The vacuum creates a pressure gradient which induces the VOCs support microbial growth. Many different methodologies have been utilized to identify applicable microorganisms, including isolation of pure strains from current contaminated situations to utilizing genetic engineering to produce a microorganism capable of degrading a specific compound. Bioremediation also comprises the stimulation of indigenous microorganisms.

Bioremediation is effective for the treatment of organic materials, such as volatile organic compounds and semivolatile organic compounds, but is not effective in treatment of inorganics, such as metals. In-situ bioremediation generally requires the addition of nutrients, oxygen, moisture and possibly the addition of microbes to the soil through wells or spread on the surface for infiltration into the contaminated material. Ex-situ bioremediation requires the addition of water and nutrients, as well as possibly microbes, to excavated soils, and rotating the soils to introduce oxygen and provide adequate contact to allow degradation of the contaminants.

One of the most important factors effecting bioremediation is the ability to biodegrade the soil contaminants. In addition, the solubility of the contaminant is also an important factor. A contaminant that is tightly adsorbed onto the particle surface, or has a very low diffusivity through the aqueous medium, can prolong the treatment time.

Initial Screening Results: Since bioremediation would not be applicable to the treatment of metals in soil and would likely not be able to reduce the levels of polycyclic aromatic hydrocarbons in the soil to remediation goals, this technology will not be considered further.

2.5.2.6 - Thermal Separation/Desorption

Technology Description: Thermal separation processes have proven effectiveness in removing volatile organic compounds, semivolatile organic compounds, PCBs and some heavy metals from soil by volatilization. The contaminants are condensed and the condensate is typically treated or disposed off site. The concentrations of organic compounds in the soil are typically reduced to levels at which the soil could be backfilled on-site. Although the levels of organics are reduced, the levels of most heavy metals would remain unchanged. Unlike solvent extraction, this process would typically not be affected by soil moisture content, although soil moisture content greater than 40% may reduce the process efficiency.

Initial Screening Results: Since thermal separation/desorption would not be applicable to the treatment of metals in the soil and would require extensive handling of the contaminated soils, this technology will not considered to be further.

2.5.3 Solidification and Stabilization

Solidification technologies may significantly reduce the mobility of inorganic contaminants, but typically do not reduce the toxicity or volume of the contaminants. These technologies may not be considered as a permanent remedy.

2.5.3.1 - Solidification

Technology Description: Solidification technologies generally utilize a cementitious matrix to encapsulate contaminants, thereby reducing their potential for leaching. These technologies treat contaminated soil with Portland cement, cement kiln, pozzolans, etc., to produce a stable material. The solidified material experiences a volume increase, generally in the range of 10 to 30%. If the solidification process is performed on-site, the stabilized material could be disposed on-site. This technology results in significant volume increases.

Initial Screening Results: Solidification of the soil at the site would require extensive material excavation and handling, and would result in a significant volume increase and would not reduce the toxicity of the soil. Therefore, this technology will not be considered further.

2.5.3.2 - Stabilization/Chemical Fixation

Technology Description: In contrast to solidification, the chemical fixation technologies utilize a process which involves more than immobilization. The process utilizes standard solidification processing; however, the volume expansion and the associated dilution are minimized.

The process can be customized to form materials ranging from pebble-sized granules to solid concrete. Volume expansion is usually in the 10 to 20% range. Volatilization of organic compounds would likely not occur due to the low heat of reaction. Although the contaminants would be "fixed" and, once treated, would not exceed TCLP levels, the total concentrations of the contaminants of concern would likely not change. Therefore, although the contaminants may not leach into the groundwater, the soil would possibly still pose a health risk. Some type of low permeability cover over the material would likely be required.

Initial Screening Results: Similar to solidification, implementation of stabilization/chemical fixation would involve extensive material excavation and handling and would result in a volume increase, would not reduce the toxicity of the soil and could also cause volatilization of the organic contaminants. Therefore, this technology will not be considered further.

2.5.4 Excavation and Removal

Technology Description: Excavation and removal would require excavation of contaminated soil and transportation to an approved/permitted secure landfill or incinerator. In addition, excavation may require construction of structural supports, such as sheeting to protect buildings, and vapor and particulate emission controls may also be required. Clean soil would be required to backfill the excavated area. This option also results in significant truck traffic and is typically costly. In addition, for the Tappan Terminal Site complete excavation would likely require removal of existing abandoned structures.

Initial Screening Results: Since removal of the contaminated soil would substantially reduce the potential for exposure to contaminated soil and impacts on groundwater, this technology would be considered further.

A summary of the identification and screening of the technologies discussed above is presented in Tables 2-1 and 2-2.

Table 2-1

SUMMARY OF INITIAL SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES
TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK

General Response Action	Remedial Technology	Description	Summary of Initial Screening Results
Extraction	Extraction Wells	Extraction wells are constructed to pump contaminated groundwater to the surface for treatment.	Retained for further consideration.
	Interceptor Trenches	Trenches are constructed to intercept shallow groundwater plumes.	Retained for further consideration.
Ex-situ Treatment	Air Stripping	VOCs are partitioned from water phase to gas phase via packed tower or aeration.	Retained for further consideration for VOC removal.
	Carbon Adsorption	Groundwater is pumped through canisters containing activated carbon.	Retained for further consideration for VOC, SVOC and pesticide removal.
	Oxidation	Contaminants are destroyed by ultraviolet radiation, ozone and/or hydrogen peroxide.	Retained for further consideration for VOC, SVOC and pesticide removal.
	Biological Treatment	Microorganisms decompose organic contaminants in treatment units.	Not retained for further consideration since more effective technologies for treatment of chlorinated organic contaminants are available.

Table 2-1 (continued)

SUMMARY OF INITIAL SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES
TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK

General Response Action	Remedial Technology	Description	Summary of Initial Screening Results
Ex-situ Treatment (continued)	Reverse Osmosis	Semi-permeable membrane and high pressure is used to obtain a concentrated solution of contaminants.	Not retained for further consideration since more effective and proven methods are available for treatment of VOC-contaminated groundwater and large volumes of reject water that would require additional treatment.
	Filtration	Suspended particles are removed by entrapment on a media (i.e., filter).	Retained for further consideration for metals removal.
	Ion Exchange	Ions are removed by substitution with alternate ions supplied by the ion-exchange material.	Retained for further consideration for metals removal.
	Chemical Precipitation and Clarification	Physical/chemical techniques are used to form insoluble settleable compounds to remove contaminants from solution.	Retained for further consideration for metals removal.
Discharge	Publicly-Owned Treatment Works	Route treated discharge to nearest municipal sanitary sewer system.	Not retained for further consideration due to discharge rate limitations.
	Off-site Transportation and Disposal of Treated Water	On-site storage and off-site transport and disposal.	Not retained for further consideration due to excessive storage and handling requirements.

Table 2-1 (continued)

SUMMARY OF INITIAL SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES
TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK

General Response Action	Remedial Technology	Description	Summary of Initial Screening Results
Discharge (continued)	Surface Water	Route treated discharge to surface water body (e.g., Hudson River).	Retained for further consideration.
	On-site Recharge/Reinjection	Discharge treated groundwater to recharge basin, injection wells or leaching pools.	Not retained for further consideration due to shallow depth to groundwater and potential interference with groundwater remediation.
In-Situ Treatment	In-Well Air Stripping	Air is injected into a well, displacing contaminated groundwater and stripping VOCs which are treated in the gas phase at the surface.	Not retained for further consideration due to potential problems with clogging and shallow depth of aquifer.
	Air Sparging	Air is injected into groundwater to strip volatile contaminants which are recovered by vapor extraction.	Retained for further consideration.
	Bioremediation/Oxygen Enhancement	Air is injected into groundwater to enhance biological decomposition of contaminants.	Not retained for further consideration due to potential problems with delivery of oxygen in subsurface, migration of degradation products in groundwater and migration of vapors into the vadose zone.

Table 2-1 (continued)

SUMMARY OF INITIAL SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES
TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK

General Response Action	Remedial Technology	Description	Summary of Initial Screening Results
In-Situ Treatment (continued)	Dual Phase Extraction	Vacuum is applied to saturated and unsaturated zones. Vapor and liquid phases are recovered and treated at surface.	Not retained for further consideration since more effective methods are available for treatment of contaminated soil and groundwater at the site.
	Chemical Oxidation	Oxidants are injected into the groundwater to treat organic contaminants.	Retained for further consideration.
	Reactive Walls	Permeable reaction wall is installed across flow path of plume to treat organic contaminants.	Not retained for further consideration due to potential impacts from tidal influences.
	Funnel and Gate	Cut-off walls are installed to direct groundwater flow to a permeable wall with treatment media which degrades the contaminants.	Not retained for further consideration due to potential impacts from tidal influences.
	Chemical Reduction	Injection of zero-valent iron to groundwater through injection wells to treat organic contaminants.	Retained for further consideration.
Containment	Slurry Walls	Soil/bentonite/cement slurry placed in excavated trench to form a barrier wall.	Retained for further consideration.

Table 2-1 (continued)

**SUMMARY OF INITIAL SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES
TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK**

General Response Action	Remedial Technology	Description	Summary of Initial Screening Results
Containment (continued)	Sheet Pile Walls	Vertical strips of steel, precast concrete, aluminum or wood driven into ground to form a barrier wall.	Not retained for further consideration due to potential for leakage between joints.
	Waterloo Barrier	Sheet piles with interlocking sealable joints driven into to ground form a barrier wall.	Retained for further consideration.
	Freeze Walls	Soil pore water frozen through the placement of thermoprobes carrying refrigerants creating a frozen barrier wall.	Not retained for further consideration due to limited long term data and equally effective and demonstrated barriers being available.

Table 2-2

SUMMARY OF INITIAL SCREENING OF SOIL REMEDIATION TECHNOLOGIES
TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK

General Response Action	Remedial Technology	Description	Summary of Initial Screening Results
Isolation/Containment	RCRA Cap	2-foot vegetated topsoil and soil layer above a geotextile over a 1-foot sand and gravel drainage layer which is underlain by a flexible membrane liner and 2-foot compacted soil/clay layer.	Not retained for further consideration since less costly, effective caps are available.
	Part 360 Cap	A four-layered system: vegetated topsoil upper layer, underlain by a drainage/barrier layer followed by a low permeability clay layer or geosynthetic membrane followed by a gas venting layer.	Retained for further consideration.
	Pavement Cap	An asphalt or concrete surface or building structure.	Retained for further consideration.
	Semi-permeable Cover	An 18-inch (10^{-5} cm/s) soil cover to mitigate direct contact with and runoff of contaminated surface soil, and reduce infiltration of precipitation.	Not retained for further consideration since the cover does not provide any significant additional benefit over a permeable cover and is more costly.

Table 2-2 (continued)

SUMMARY OF INITIAL SCREENING OF SOIL REMEDIATION TECHNOLOGIES
TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK

General Response Action	Remedial Technology	Description	Summary of Initial Screening Results
Isolation/Containment (continued)	Permeable Cover	A 2-foot (>10^{-5} cm/s) soil and/or gravel/stone cover to mitigate direct contact with and runoff of contaminated surface soil.	Retained for further consideration.
Treatment	Soil Washing	Soil is physically separated and fine fraction is washed to transfer contaminants into solution.	Not retained for further consideration due to inability at this site to effectively separate contaminated fraction from the uncontaminated fraction.
	In-situ Soil Washing	Water is applied to the unsaturated soil or injected into the groundwater to raise the water table into the contaminated zone and leached contaminants are removed.	Not retained for further consideration due to the potential for mobilization of contaminants, difficulties with separation and treatment of the flushing fluids, and limited use on full-scale level.
	Soil Vapor Extraction	A vacuum is applied to the subsurface and extracted air is treated for VOCs.	Retained for further consideration.
	Bioremediation	Microorganisms degrade organic contaminants.	Not retained for further consideration because it is not effective for the treatment of metals.

Table 2-2 (continued)

SUMMARY OF INITIAL SCREENING OF SOIL REMEDIATION TECHNOLOGIES
TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK

General Response Action	Remedial Technology	Description	Summary of Initial Screening Results
Treatment (continued)	Thermal Separation/ Desorption	Contaminants are thermally desorbed and condensed, and the condensate is treated or disposed off-site.	Not retained for further consideration due to the extensive excavation and handling requirements, and inability to treat metals.
Solidification and Stabilization	Solidification	A cementitious matrix is used to encapsulate contaminants and reduce leaching potential.	Not retained for further consideration due to extensive excavation and handling requirements resulting volume increase and no reduction in toxicity of soil.
	Stabilization/ Chemical Fixation	Chemical additives and processes are used to immobilize contaminants with minimum volume expansion.	Not retained for further consideration due to extensive excavation and handling requirements and no reduction in toxicity of soil.
Excavation and Removal	Off-site Disposal	Contaminated soil is excavated and transported to a permitted landfill or treatment facility.	Retained for further consideration.

2.6 Summary Evaluation of Remedial Technologies

Based on the screening of remedial technologies, provided below is a summary of the technologies that are retained for further consideration. Groundwater and soil technologies will continue to be evaluated separately in order to ensure appropriate selection of the best technology for each media. In addition to the technologies listed below, no action and institutional controls will also be evaluated further.

Groundwater Remediation

- Extraction technologies
  - wells
  - interceptor trenches

- Ex-situ treatment technologies
  - air stripping
  - carbon adsorption
  - UV oxidation
  - filtration
  - ion exchange
  - chemical precipitation and clarification

- Discharge options
  - discharge to surface water

- In-situ treatment technologies
  - air sparging
  - chemical oxidation
  - chemical reduction
  - containment barrier

- Contaminant Technologies
  - slurry walls
  - waterloo barrier

Waste/Soil Remediation

- Isolation/containment technologies
  - Part 360 cap
  - pavement cap
  - permeable cover

- Treatment technologies
  - soil vapor extraction

- Excavation and removal

Section 3

3.0 SUPPLEMENTAL INVESTIGATION

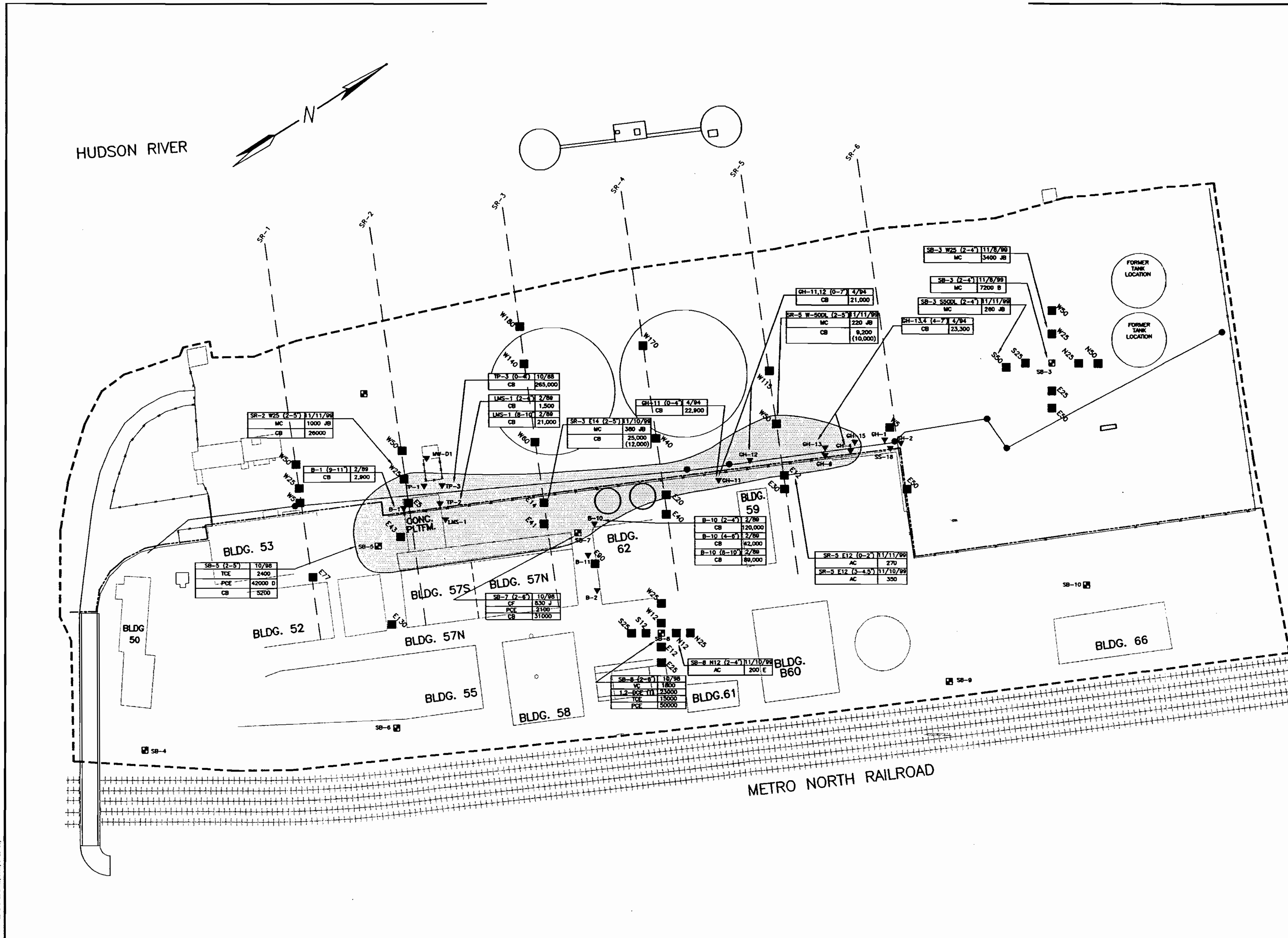
A supplemental field investigation was conducted at the Tappan Terminal Site to further delineate subsurface soil contamination in three areas of concern identified in the remedial investigation. The three areas were in the vicinity of soil borings SB-5, SB-7 and SB-8 (see Figure 3-1). Soil samples collected from these borings indicated the presence of volatile organic compounds in exceedance of SCGs. In addition to these three areas of concern, SB-3 was visually characterized as containing petroleum-like material and was also considered a potential area of concern. Groundwater samples were also collected as part of the supplemental investigation to further delineate the chlorobenzene plume identified in the area of a former chlorobenzene storage tank and the former sanitary sewer, which traverses the site. Additionally, surface soil samples were collected and analyzed for PCBs to determine the extent and sources of PCB contamination.

3.1 Surface Soil

Surface soil sample results obtained during the remedial investigation indicated the presence of PCBs in surface soils on the Tappan Terminal Site. Although no sources for PCBs have been identified on the site, historical aerial photography and site maps suggest that vehicle traffic may have once passed between the ARCO and Tappan Terminal Sites thus providing a potential route for migration of PCBs from the ARCO property to the Tappan Terminal Site.

In order to evaluate the possible presence of PCBs along this migration route and to attempt to establish a source for PCBs previously detected on the Tappan Terminal Site, 15 surface soil samples were collected. All samples were shipped to an off-site laboratory and analyzed for PCBs. The 15 surface soil samples were collected from three locations as shown in Figure 3-2 and described below.

Four surface soil samples were collected beneath the paved roadway at the west end of the bridge that crosses the Metro-North Commuter Railroad tracks at the southeast end of the Tappan Terminal Site. This bridge is the only means of ingress and egress from the Tappan



LEGEND

ABBREVIATION	COMPOUND	SOIL SCG (ug/kg)
AC	ACETONE	200
1,2-DCE (T)	1,2-DICHLOROETHENE (TOTAL)	300
MC	METHYLENE CHLORIDE	100
CF	CHLOROFORM	300
TCE	TRICHLOROETHENE	700
PCE	TETRACHLOROETHENE	1400
CB	CHLOROBENZENE	1700
VC	VINYL CHLORIDE	200

■ SUBSURFACE SOIL SAMPLE DURING SUPPLEMENTAL RI- NOVEMBER 1999

SUBSURFACE SOIL SAMPLE DURING RI - OCTOBER 1998

▼ SUBSURFACE SOIL SAMPLE DURING INVESTIGATIONS PRIOR TO OCTOBER 1998

AREAS OF CHLOROBENZENE ABOVE SCGs

DEPTH OF SAMPLE — DATE COLLECTED — SAMPLE ID — SB-9 (1-4') 10/98 — CB ND — ANALYTE — CONCENTRATION IN ug/Kg

ND NOT DETECTED

J VALUE ESTIMATED

B COMPOUND FOUND IN BLANK AS WELL AS SAMPLE

E RESULT EXCEEDS CALIBRATION LIMITS

D VALUE IS A RESULT OF ANALYSIS WITH DILUTION

NOTE: VOC ANALYSES WERE CONDUCTED ON ALL SUBSURFACE SOIL SAMPLES COLLECTED IN NOVEMBER 1999 AND DEPICTED ON THIS DRAWING. UNLESS OTHERWISE NOTED, THERE WERE NO EXCEEDANCES FOR VOC'S IN SUBSURFACE SOIL SAMPLES COLLECTED IN NOVEMBER 1999.

VALUES PRESENTED WERE OBTAINED FROM THE MOBILE LABORATORY. VALUES OBTAINED FROM OFF-SITE LABORATORY ARE NOTED IN PARENTHESIS.

0 50' 100' 150'

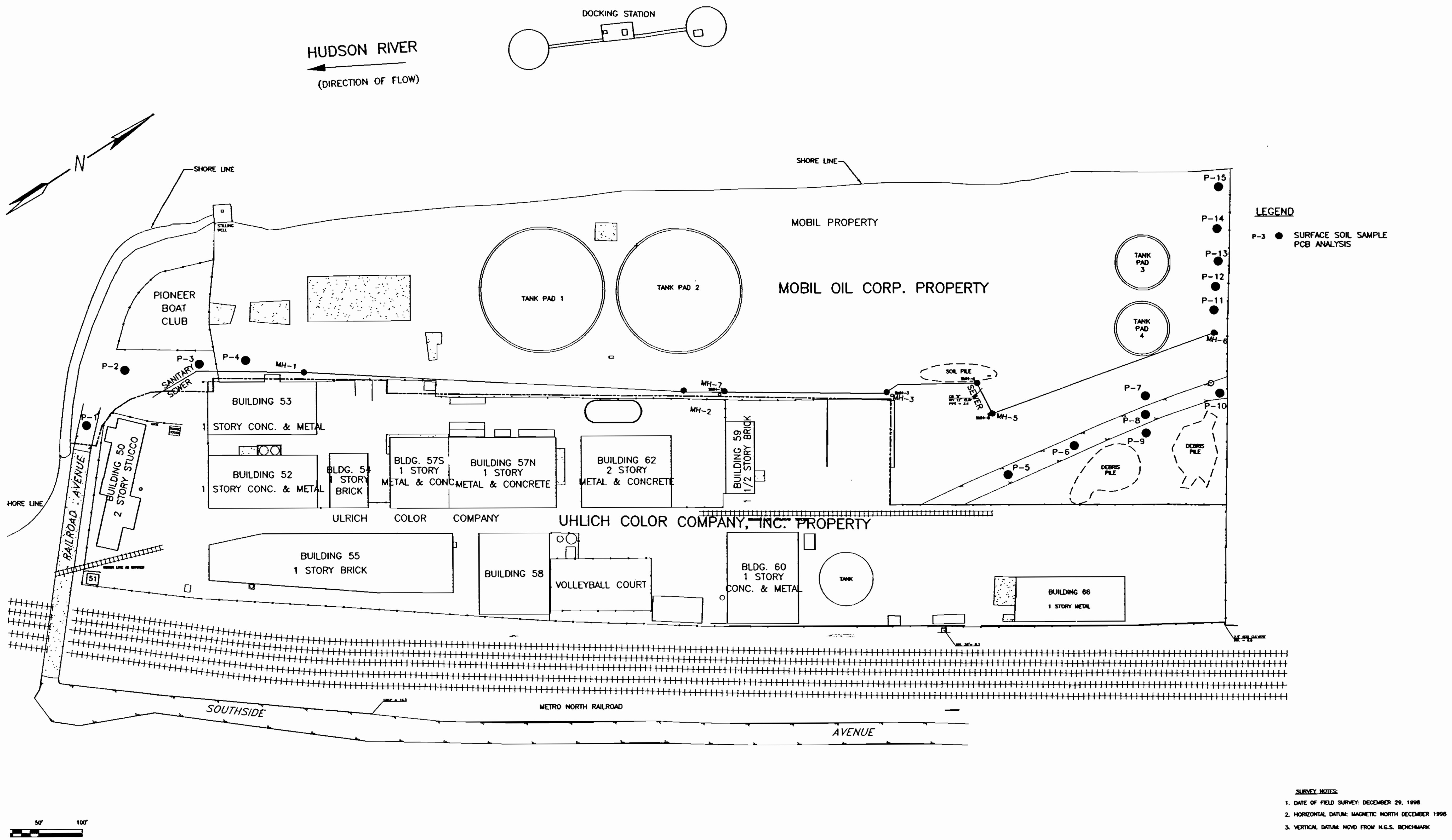
SCALE IN FEET

TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK

VOC EXCEEDANCES OF STANDARDS, CRITERIA & GUIDELINES IN SUBSURFACE SOIL

Dvirka and Bartilucci
Consulting Engineers
A Division of William F. Cosulich Associates, P.C.

FIGURE 3-1



TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK

Dvirka and Bartilucci
Consulting Engineers
A Division of William F. Cosulich Associates, P.C.

PCB SAMPLE LOCATIONS—SUPPLEMENTAL SOIL INVESTIGATION

FIGURE 3-2

Terminal Site and would likely have been used by vehicles entering or exiting the ARCO Site to the north. Six samples were collected beneath and adjacent to a paved roadway that connects the Uhlich property on the Tappan Terminal Site to the south edge of the ARCO property. This road is currently unused and is blocked on the north by a locked gate at the ARCO property line and at the southeast by a locked gate at the Uhlich property line. Five surface soil samples were collected along the Tappan Terminal Site side of the fence that separates the two properties. These samples were collected outside of the containment berm at the northwest portion of the Mobil property portion of the Tappan Terminal Site.

3.2 Subsurface Soil

During the supplemental subsurface soil investigation, 42 borings were constructed on the Tappan Terminal Site. A total of 84 subsurface soil samples were collected and screened visually for contamination and volatile organic vapors using a photoionization detector (PID). Of these subsurface soil samples, 62 samples exhibiting elevated levels of organic vapors were selected for gas chromatograph (GC) analysis in an on-site, mobile laboratory operated by Streamlined Site Characterization and Closure (S_2C_2, Inc.). Several samples exhibiting elevated PID readings were not analyzed on-site because they exhibited high concentrations of petroleum-like substances that may have contaminated the analytical equipment or other samples awaiting analysis. The remaining samples not analyzed were samples that exhibited no evidence of contamination during field screening and were likely to result in low levels of contamination based on the analysis of similar samples.

Each sample was collected using direct push sampling methods and a macro core sampler. Soil samples were obtained by cutting the macro core tube longitudinally. The tube was opened slightly to allow measurement with a PID. After the PID measurements were recorded, the tube was wedged open so that visual and odor observations could be conducted. The soil sample was then logged and samples removed and placed in sample containers. Samples were collected for analyses based on the degree of contamination observed through visual and PID screening. In all cases, efforts were made to collect the most contaminated soil observed in the sample tube. The containers were then taken to the on-site laboratory and refrigerated until the analyses were run. In most cases the samples were analyzed within one hour of collection.

The GC was calibrated for five target compounds identified as a result of the remedial investigation which included trichloroethene, 1,1 dichloroethene, toluene, chlorobenzene and benzene. Once screened by GC, several samples were selected for analysis by gas chromatograph/mass spectrometry (GC/MS) in the mobile laboratory using Method 8260B. Samples run by GC/MS were chosen because they exhibited either high or low concentrations of the target compounds. Samples with undetectable concentrations of target compounds were run by GC/MS to confirm the GC results. Five samples analyzed by GC/MS in the mobile laboratory were forwarded to an off-site laboratory for confirmatory analysis.

3.2.1 Sewer Line

The area of concern in the vicinity of soil borings SB-5 and SB-7 is near the former sanitary sewer line that ran through the Mobil property roughly parallel to the Uhlich/Mobil property line. This sewer line was reportedly damaged and partially removed during excavation of contaminated soil from the Mobil property in 1994. This sewer line may have been and may still be acting as a conduit for contaminant migration from source areas. The sewer line was therefore the target of the supplemental investigation.

Historical data indicated that the contamination along the sewer line is limited to the area south of MH-3 (see Figure 3-1) and north of MH-1, and therefore, the investigation was limited to the area between MH-1 and MH-3

The supplemental sampling was conducted along six lines located perpendicular to the sewer line between MH-1 and MH-3 to define the extent of the subsurface soil contamination (see Figure 3-1). Direct push borings were constructed on or near each perpendicular line. The lines are designated SR-1, SR-2, SR-3, SR-4, SR-5 and SR-6, and are approximately 130 feet apart. Along each line, one boring was located over, or adjacent to the sewer line with two borings located east and two borings located west of the sewer line. Subsurface soil samples were collected from depths of 0-6 feet using a macro core sampler at each location. Groundwater was encountered at depths of 4 to 6 feet at each location. Sampling locations and the number of samples collected were determined based on field observations, and modified as necessary to define the extent of the contamination. The following provides the details of the sampling performed along each line.

Sample Line SR-1

Two sample attempts initially were made inside of Building 53 to determine if contaminated soil or groundwater were present beneath the building. Both attempts failed due to sampler refusal in concrete foundation material. The concrete was penetrated at least 24 inches in one location and 12 inches in the other without break-through. The samples were relocated outside of the east wall of the building. Sample location SR1-5W is located over the sewer line and encountered a fine sand material, different from typical fill material found in other borings on-site. This fill material may be bedding material for the sewer pipe.

Sample Line SR-2

Samples along SR-2, east of the sewer line, were abandoned due to an impenetrable concrete pad below the asphalt parking surface. The boring was relocated to the south of the sample line. Uhlich employees indicated that there may be a buried tank cradle and pad in this area.

Sample Line SR-3

This line runs through the location of the former one million gallon above ground storage tank on the Mobil property. The tank pad was filled with rain water at the onset of this investigation and was dewatered in order to expose the ground surface and allow access for the drill rig. Once the water was removed, samples were collected by penetrating the concrete pad and collecting subsurface soil.

Sample Line SR-4

The west end of this sample line was bounded by monitoring well (OW-9A) that previously had been found free of chlorobenzene. The east end of this line was bounded by a direct push sample (GW-4) collected during the remedial investigation.

Sample Line SR-5

Sampling along this sample line was discontinued when a non-detectable concentration of chlorobenzene was found on the east side of the sewer line.

Sample Line SR-6

Direct push sampler refusal occurred on the east side of SR-6 and sampling was discontinued. This area was reportedly remediated in the past and clean soil is presumed to exist at this location. Samples from SB-3, as well as nearby monitoring wells, provide data for this line.

3.2.2 Area Surrounding Soil Boring SB-3

Another area of concern that was further delineated in the supplemental investigation was subsurface petroleum-like contamination observed near SB-3. Supplemental sampling included the collection of subsurface soil from four locations placed at a distance of 25 feet north, east, south and west of SB-3. Samples from each of the locations exhibited petroleum-like contamination, including elevated PID measurements, petroleum-like odors and dark, oily-like liquid between soil grains. As a result, four additional samples were collected from locations 50 feet away from SB-3. These samples also exhibited similar petroleum-like characteristics.

3.2.3 Area Surrounding Soil Boring SB-8

Elevated levels of tetrachloroethene, trichloroethene and 1,2-dichloroethene were detected in subsurface soil collected from SB-8 during the remedial investigation. Supplemental investigation sample locations were placed along lines that trend north-south and east-west through SB-8. The initial points were located approximately 25 feet from the center of the original boring. Four additional samples were collected along the same lines, but at a distance of 12 feet from SB-8. One additional sample was collected 2 inches north of the original SB-8 location.

3.3 Groundwater

As recommended in the remedial investigation report, a sample of light non-aqueous phase liquid (LNAPL) observed at monitoring well LMS-2 was collected for fuel fingerprint analysis.

Groundwater samples were also collected using direct push techniques to further define the chlorobenzene plume identified in the RI report. Samples were collected from the bottom of each of the subsurface borings in each of the areas of concern. All samples were screened in the on-site laboratory using the GC or GC/MS.

A total of 37 groundwater samples were collected from direct push borings during the supplemental investigation. The samples were screened on the on-site laboratory GC and 34 samples were selected for analysis on the GC/MS. Three samples were sent to an off-site laboratory for confirmation of the on-site laboratory results.

3.4 Nature and Extent of Contamination

The purpose of this section is to provide a discussion of the sampling results obtained as a part of the supplemental field investigation conducted at the Tappan Terminal Site. The results are compared to standards, criteria and guidelines selected for the site to determine potential impacts on human health and the environment. These are the following: surface and subsurface soil – NYSDEC Technical and Administrative Guidance Memorandum (TAGM) 4046 "Determination of Soil Cleanup Objectives and Cleanup Levels" dated January 1994 and Groundwater – NYSDEC Technical and Operational Guidance Series (TOGS 1.1.1) "Ambient Water Quality Standards and Guidance Values," dated June 1998. Some groundwater samples obtained from portions of the site are influenced by tides in the Hudson River and probably have chloride concentrations above 250,000 micrograms per liter (ug/l). These groundwater samples are saline or Class SGA; however, Class GA standards, that are protective of potable water and are more stringent than those for Class SGA, were used for screening groundwater sample analyses. The nature and extent of contamination found at, and in the vicinity of the site during the supplemented investigations, based on comparison to the SCGs, is described below.

The analytical results are presented and discussed as a function of media. The following sections describe exceedances of SCGs only. Tabulated results for all analyses, including results below SCGs, are presented in Appendix A.

3.4.1 Surface Soil

A total of 15 surface soil samples were collected at the locations indicated on Figure 3-2. Surface soil samples were collected at a depth of 0 to 3 inches below ground surface at locations where soils were exposed at ground surface. Samples collected from beneath pavement were obtained from depths 3 to 6 inches below the bottom pavement surface.

Seven surface soil samples exhibited exceedances of the SCG for PCBs (1,000 μg/kg). Samples P-8, P-11, P-12 and P-13 exhibited concentrations of Aroclor 1260 ranging from 1,300 to 3,000 μg/kg. Samples P-11, P-12 and P-13 exhibited concentrations of Aroclor 1254 ranging from 1,500 to 2,000 μg/kg. Sample P-14 exceeded SCG for total PCBs, but did not exceed SCGs for any single Aroclor.

3.4.2 Subsurface Soil

Sixty-two subsurface soil samples were collected from direct push soil borings performed on the site. Subsurface soil samples were collected between the ground surface and the water table from depths of 0 to 5 foot below ground surface. One sample was collected from the 0 to 2 foot interval and a second sample was collected from the 2 to 5 foot interval.

Sewer Line

Results of GC screening of samples near the sewer line indicate three samples exhibiting exceedances for SCGs for target compounds. Chlorobenzene was the only compound detected and was identified in SR2-W25 (26,000 μg/kg), SR3-E14 (25,000 μg/kg) and SR5-W50 (9,200 μg/kg). Each of these samples were collected from the 2 to 5 foot interval. Methylene chloride was also detected above SCGs in the GC/MS analyses of SR2-W25 (1000 μg/kg) and SR3-E14 (380 μg/kg). Acetone concentrations exceeded SCGs in SR5-E12 (0-2') and SR5-E12(3-4.5') at concentrations of 270 μg/kg and 350 μg/kg, respectively.

Area Surrounding Soil Boring SB-8

Fourteen subsurface soil samples were collected in the vicinity of SB-8. One sample exhibited an exceedance of SCGs for acetone. Sample SB8-N12 (2'-4') exhibited an acetone concentration of 200 μg/kg. No other VOCs were detected above SCGs in this area.

Area Surrounding Soil Boring SB-3

Methylene chloride was identified above SCGs near SB-3. Samples SB3, SB3-N50 and SB3-W25 exhibited methylene chloride at concentrations of 7,200 μg/kg, 260 μg/kg and 3,400 μg/kg, respectively. Review of blank information indicated the detections of methylene chloride were a result of laboratory contamination. Sample SB3-W25 exhibited the presence of chlorobenzene at 2,200 ug/kg. All samples collected below 2 feet ground surface were observed to exhibit petroleum-like characteristics. Table 6 in Appendix A lists subsurface sample locations at which petroleum-like contamination was observed during sample collection.

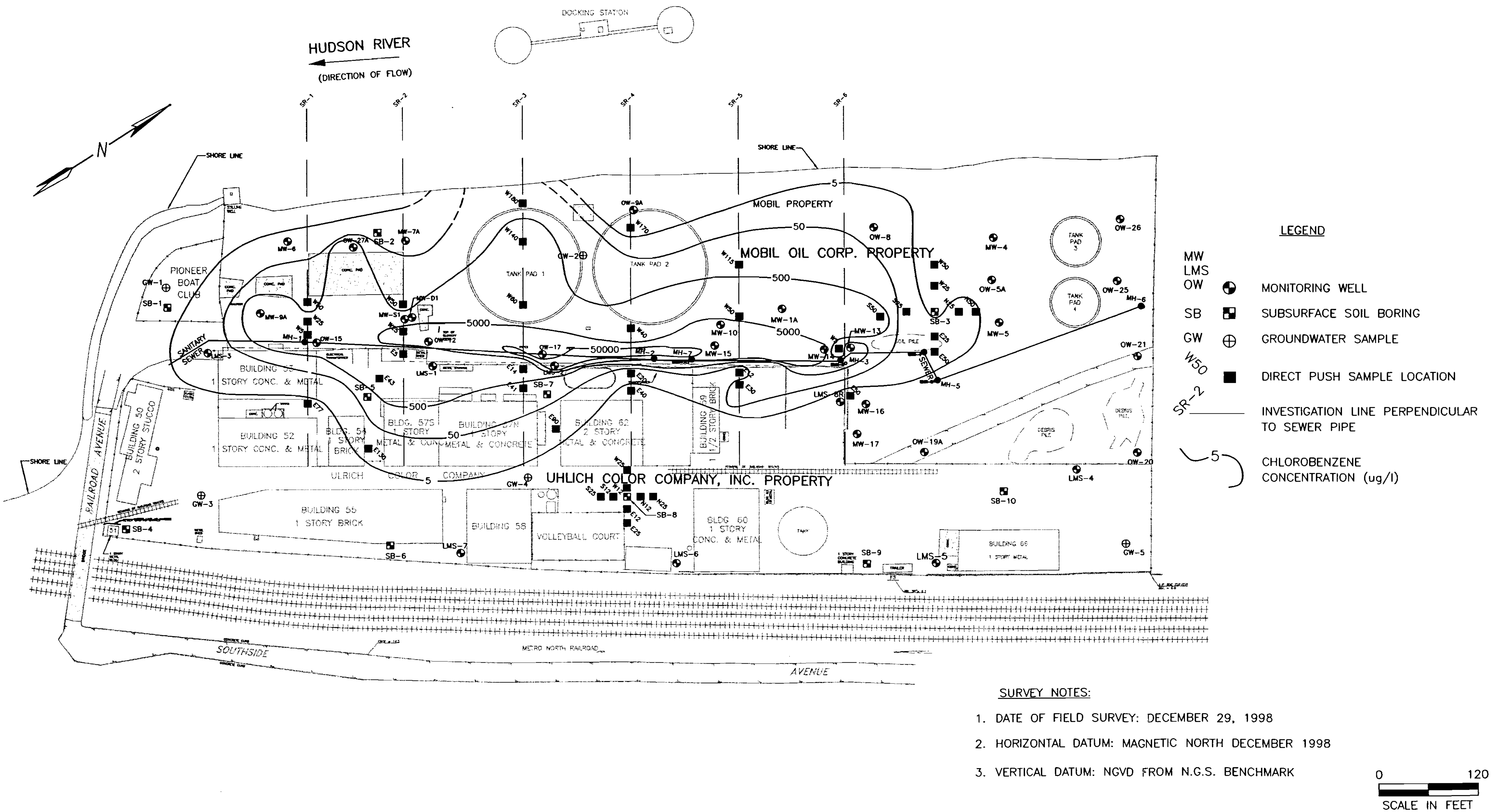
3.4.3 Groundwater

A total of 37 groundwater samples collected from direct push sampling probes were analyzed during the supplemental investigation. Figure 3-3 summarizes the concentrations of chlorobenzene in groundwater at the site. Tables of the results are provided in Appendix A.

Ten VOCs were identified at concentrations exceeding SCGs for groundwater. Of the 10 VOCs found in exceedance of SCGs, chlorobenzene, benzene, methylene chloride, acetone and naphthalene were the only compounds that exceeded the SCGs in more than one sample. Chlorobenzene exceedances (SCG of 5 µg/l) were identified in 21 samples. The highest concentrations were identified at sample locations near the former chlorobenzene tank. Exceedances of SCGs for chlorobenzene range from 12 µg/l to 6,800 µg/l near the former tank location.

Benzene was identified in exceedance of SCGs (1 µg/l) in 11 samples, all located along the abandoned sewer line. Benzene concentrations range from 1.4 µg/l to 190 µg/l on the Mobil property. Benzene is a likely breakdown product of chlorobenzene. Methylene chloride was identified above SCGs (5 µg/l) in nine samples with concentrations ranging from 7.9 µg/l to 290 µg/l.

Naphthalene was detected above its SCG of 5 µg/l in four samples near the abandoned one million gallon tank pad and is likely the result of fuel oil spills in this area. Naphthalene concentrations ranged from 30 µg/l to 650 µg/l in SR4-W40. Acetone was also identified above its SCG of 50 µg/l in SR3-E41 (110 µg/l) and SR5-W115 (68 µg/l).



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TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK

CHLOROBENZENE CONCENTRATIONS IN GROUNDWATER

Dvirka and Bartilucci
Consulting Engineers
A Division of William F. Cosulich Associates, P.C.

FIGURE 3-3

Chloroform (11 μg/l in SR3-E14), trichloroethene (110 μg/l in SR3-E14), toluene (130 μg/l in SR4-W40), tetrachloroethene (21 μg/l in SR3-E14) and ethylbenzene (12 μg/l in SR5-W50) and were detected at concentrations above SCGs in only one sample each.

The result of the fuel fingerprint analysis of the LNAPL sample collected from LMS-2 indicated the product contained peaks in the retention time range of a typical diesel fuel.

3.5 Conclusions

3.5.1 Surface Soil

Areas where elevated levels of PCBs were detected on the Uhlich property will be considered for remediation.

3.5.2 Subsurface Soil

Subsurface soils in the area of concern along the sewer line exhibited elevated levels of chlorobenzene extending from the former chlorobenzene tank area to approximately 400 feet north of the Tank (see Figure 3-1). This area will be considered for remediation.

The elevated levels of chlorinated hydrocarbons identified in the remedial investigation in the vicinity of SB-8 were not confirmed, and therefore, this area will not be considered further as an area of concern.

In addition, although slightly elevated levels of chlorobenzene were detected in the vicinity of SB-3, since the exceedance was only detected in one diluted sample, this area will not be considered for remediation.

Each of the nine soil samples collected in the vicinity of soil boring SB-3 indicated the presence of petroleum contamination. The petroleum contamination was identified based on visual screening of the soils for petroleum-like characteristics, including odor, sheen and elevated PID measurements. While petroleum contamination was detected in the vicinity of SB-3, it appears that this is not an isolated area of petroleum-contaminated soil. Sixteen of the 22 samples collected on the Mobil property indicated the presence of petroleum-like contamination.

Since it appears that petroleum contamination is widespread on the Mobil property and that the petroleum is not having a significant impact on groundwater, this contamination will be addressed as part of the overall site remediation discussed in the following sections.

3.5.3 Groundwater

Results of the supplemental investigation indicate that the areal extent of chlorobenzene contaminated groundwater is larger than depicted in the remedial investigation report. The area of contaminated groundwater appears bounded by the sewer line to the east and the Hudson River to the west. The migration of contaminated groundwater may be influenced by buried structures, such as former seawalls; however, it appears that chlorobenzene is migrating into the Hudson River.

Section 4

4.0 DEVELOPMENT AND PRELIMINARY EVALUATION OF ALTERNATIVES

Based on the screening of remedial technologies in Section 2.0, the next phase of the feasibility study process is to develop remedial alternatives for preliminary evaluation based on effectiveness, implementability and relative cost. These alternatives can comprise either a single technology if only one medium at a site is of concern and/or only one treatment process is required, or a combination of technologies if multiple media are of concern and/or multiple treatment processes are required.

As described previously, the media of concern identified at the Tappan Terminal Site are surface/subsurface soil and groundwater. The Uhlich Color Company is currently an active industrial facility and will likely continue to be an active facility. The Mobil property is no longer being utilized for industrial purposes and the future use of the property is currently undecided. Although the surface/subsurface soil and groundwater on both properties requires remediation, remediation of the media on each of the properties must be evaluated differently due to the current and potential future uses of the property. Remediation of the surface/ subsurface soil and groundwater on the Uhlich property must be implemented without disruption of current activities. Therefore, although several soil remedial technologies were retained for further evaluation, the only form of soil remediation that will be evaluated for the Uhlich property will be select excavation and off-site disposal of chlorobenzene contaminated soil from areas that would not impact active buildings or structures, and maintenance and repavement of the existing pavement/structure cover to eliminate potential for exposure to contaminated surface soil and to mitigate migration of precipitation through contaminated subsurface soil. The same groundwater alternatives will be evaluated for both the Uhlich and Mobil properties; however, active remediation will not take place beneath active structures on the Uhlich property. Relatively low levels of contaminants are present beneath these structures and it is anticipated that contamination on the Uhlich property upgradient of the sewer line will attenuate or be captured by the remediation occurring along the sewer line.

Since the Mobil property is not currently being utilized and a future use of the property is not yet decided, several of the soil technologies retained for further evaluation may be potentially applicable and will be further evaluated in this section.

Groundwater and soil alternatives will be evaluated separately in this section. Once the preliminary evaluation is performed, the remaining soil and groundwater alternatives may be combined to form alternatives for remediation of the site. Six alternatives have been developed for remediation of soil contamination and four alternatives have been developed for remediation of groundwater contamination. A description of these alternatives, and the remedial technologies that form these alternatives, is provided below.

4.1 Description of Remedial Alternatives

4.1.1 Soil Remediation Alternatives

As a result of the Preliminary Screening of Technologies, the following six soil alternatives have been developed for remediation of soil contamination at the Tappan Terminal Site.

Soil Remediation Alternatives

S1 - No action

S2 - Institutional controls

S3 - Part 360 cap (Mobil property) and pavement cap (Uhlich property)

S4 - Soil cover (Mobil property) and pavement cap (Uhlich property)

S5 - Hot spot excavation and off-site disposal (Mobil and Uhlich property), soil cover (Mobil property) and pavement cap (Uhlich property)

S6 - Partial excavation and off-site disposal (Mobil property), hot spot excavation and off-site disposal (Uhlich property), and pavement cap (Uhlich property)

4.1.1.1 - Alternative S1 – No Action

This alternative provides no active remediation and relies solely on natural attenuation for reduction of contamination in soil.

4.1.1.2 - Alternative S2 – Institutional Controls

This alternative provides for maintenance of the existing fencing along the northern, southern and eastern boundaries of the site, installation of a fence along the western site boundary along the Hudson River, and posting of signs to warn the public of the presence of contaminated soil. This alternative also includes placement of institutional/land use controls, such as zoning and deed restrictions, to ensure appropriate future use of the property that will protect human health. The property is currently zoned industrial and a zoning restriction may include ensuring that the zoning for the site is not changed.

4.1.1.3 - Alternative S3 – Part 360 Cap (Mobil property) and Pavement Cap (Uhlich property)

This alternative provides for the placement of a low permeability geomembrane cap over the 7.7 acres of the Mobil property. The cap will be constructed consistent with the NYSDEC Part 360 regulations and will consist of, from bottom to top:

- 6-inch minimum sand cover/liner cushion material;
- 60-mil high density polyethylene (HDPE) liner
- geocomposite drainage layer
- 24-inch barrier protection layer; and
- 6-inch vegetative growth medium, or asphalt or concrete pavement, or buildings

Liner cushion material will be clean, well graded granular material free from any organic material, roots, clay, construction and demolition debris, or other material which could damage the geomembrane liner. The HDPE liner will be placed directly on top of the granular material. The geocomposite drainage layer will consist of a drainage net and geotextile combination, which will serve as a medium to promote drainage off the liner. The barrier protection layer will provide protection of the liner. The final layer of the cap will be topsoil and a vegetative cover, asphalt or concrete pavement, or building structures depending on development of the site. To achieve a grade of 4 percent to promote drainage off the liner, fill material would need to be brought to the site and graded, and the final elevation in the areas capped will be approximately 8 to 10 feet above the existing grade. A grade of 2 percent would result in a maximum elevation of about 4 to 5 feet above existing grade.

Areas on the Uhlich property where asphalt paving is in disrepair (or non-existent) will be covered with new asphalt pavement. Storm water runoff from the site will comprise sheet flow over a portion of the site directly to the Hudson River and drainage in a swale along the eastern boundary of the Mobil property also to the river.

Once the cap is completed, periodic inspection, as well as maintenance and repair of the cap, will be required for 30 years. Placement of institutional controls, such as fencing, zoning and deed restrictions to ensure appropriate future use of the property and protection of the liner and pavement, is also be included as part of this alternative.

4.1.1.4 - Alternative S4 – Soil Cover (Mobil property) and Pavement Cap (Uhlich property)

This alternative includes the placement of a 2-foot clean soil (or stone/gravel) cover over all exposed soil, which involves approximately 7.7 acres of the site. As discussed above, paved areas on the Uhlich property which are in disrepair will be repaved, fencing will be placed along the western boundary of the site and institutional controls will be included as part of this alternative.

4.1.1.5 - Alternative S5 –Hot Spot Excavation and Off-site Disposal (Mobil and Uhlich property), Soil Cover (Mobil property) and Pavement Cap (Uhlich property)

Soil contaminated with chlorobenzene along the sewer line, defined as the "hot spot", will be excavated to the water table and disposed of off-site (see Figure 3-1). The total volume of soil requiring excavation is estimated to be 7,000 cubic yards (cy). As shown on Figure 3-1, the area of chlorobenzene contamination is estimated to extend under several active and inactive on-site structures, such as tank pads and concrete platforms. The abandoned structures overlying contaminated soil will be removed prior to excavation of the soil. Precautions will be taken to remove soil surrounding active structures on the Uhlich property without impacting the integrity of the structures. Off-site disposal of the debris from demolition of the abandoned structures will likely be required. All excavated areas will be backfilled with clean soil.

In addition to the "hot spot" soil removal, a 2-foot soil cover will be placed over the 7.7 acre Mobil property in order to mitigate contact with contaminated soil not being removed. Paved areas on the Uhlich property that are in disrepair will be repaved.

Since chlorobenzene is a volatile organic compound, it may be necessary to install temporary vapor control structures or other suppression measures over the areas of excavation in order to mitigate the potential for off-site release of contaminated vapors. Organic vapor monitoring will be performed during excavation of contaminated soil. Dust control will also be required during excavation of the soil. Soils may require periodic wetting or other control measures to mitigate dust emissions. During excavation, stockpiled soils will require liners, covers and erosion controls. Dust suppression and particulate monitoring will be performed in accordance with Division of Hazardous Waste Remediation (DHWR) Technical and Administrative Guidance Memoranda (TAGM) 4031 – Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites. During excavation, workers may be required to conduct work in levels of personal protective equipment higher than Level D (i.e., Level C or B). Site monitoring will be performed to determine the appropriate levels of personal protective equipment required.

Since all of the contaminated soil will not be removed off-site, institutional controls, such as fencing and deed and zoning restrictions, will also be included as part of this alternative.

4.1.1.6 - Alternative S6 –Partial Excavation and Off-site Disposal (Mobil property), Hot Spot Excavation and Off-site Disposal (Uhlich property) and Pavement Cap (Uhlich property)

Soil to the depth of the water table (average of 5 feet) will be excavated from the 7.7 acres of the Mobil property. This would result in about 60,000 cy of soil that would require off-site disposal.

The remaining hot spot area along the sewer line exhibiting elevated levels of chlorobenzene on the Uhlich property will also be excavated to the water table and removed off-site. The total volume of soil estimated to require excavation from this area is approximately 5,000 cy. Any abandoned structures located above the contaminated soil, such as tank pads or platforms, will be removed prior to excavation of soil. Precautions will be taken to maintain active structures while removing surrounding contaminated soil. All excavated areas will be backfilled with clean soil to existing grade.

Appropriate precautions will be taken during excavation of contaminated soil to mitigate vapors and dust from migrating off-site and/or impacting on-site workers.

Remaining areas on the Uhlich property, where pavement is in disrepair, will be repaved. Since all of the contaminated soil will not be removed off-site, institutional controls will also be included as part of this alternative.

4.1.2 Groundwater Alternatives

At the completion of the Phase I Feasibility Study, a number of groundwater extraction and treatment remediation technologies, and treated groundwater discharge options were selected for further evaluation. Some of these technologies have been combined to form alternatives, while other technologies are not being considered further.

With regard to the extraction technologies, a two dimensional model (MODFLOW) was utilized to approximate the extraction rate required to capture the contaminant plume. Both wells and interceptor trenches were simulated in the model to determine which method would be the most effective. Based on the results of the model, it was determined that the use of six shallow extraction wells pumping between 10 and 20 gallons per minute would be the most effective method for capture of the plume. As a result, interceptor trenches will not be evaluated further.

With regard to treatment technologies, experience in groundwater remediation indicates that the following technologies would be most applicable to remediate the contaminants of concern at the site to the limits set for discharge to the Hudson River, these being: aeration/air stripping and carbon adsorption for VOC and SVOC removal and chemical precipitation and clarification for metals removal. As a result, UV oxidation, filtration and ion exchange will not be considered further.

Two containment technologies remained after the preliminary screening of technologies. The two barriers remaining are the slurry wall and the Waterloo Barrier. Although either of the barriers would be appropriate for use at the Tappan Terminal Site, the slurry wall would generally be less expensive to install and due to the potential for encountering subsurface obstructions, such as buried foundations and old bulkheads, which may impede installation of the Waterloo Barrier, a slurry wall will be used in the development of alternatives for the site.

Three in-situ groundwater remediation technologies were retained for further consideration at the completion of the Phase I Feasibility Study, these being air sparging with soil vapor extraction, chemical oxidation and chemical reduction. Air sparging combined with soil vapor extraction is the most proven of the four in-situ technologies and, therefore, will be considered further. Of the remaining two technologies, chemical oxidation would likely be the most effective at reducing the elevated levels of chlorobenzene in groundwater to below standards/guidelines. Although potentially applicable to the site, chemical reduction is likely not to be as effective as air sparging/soil vapor extraction at sites with significantly elevated levels of chlorinated contaminants. Although chemical oxidation is an emerging technology, based on available information, it would likely be more effective than chemical reduction. Therefore, chemical reduction will not be evaluated further.

As a result of this further evaluation of remedial technologies, the following four alternatives have been developed for remediation of groundwater contamination at the Tappan Terminal Site:

Groundwater Remediation Alternatives

G1 – No action with long-term groundwater monitoring

G2 – Air sparging with soil vapor extraction and long-term groundwater monitoring

G3 – Hydraulic barrier, extraction and treatment, and discharge to the Hudson River and long-term groundwater monitoring

G4 – In-situ chemical oxidation and long-term groundwater monitoring

4.1.2.1 - Alternative G1 - No Action with Long-Term Groundwater Monitoring

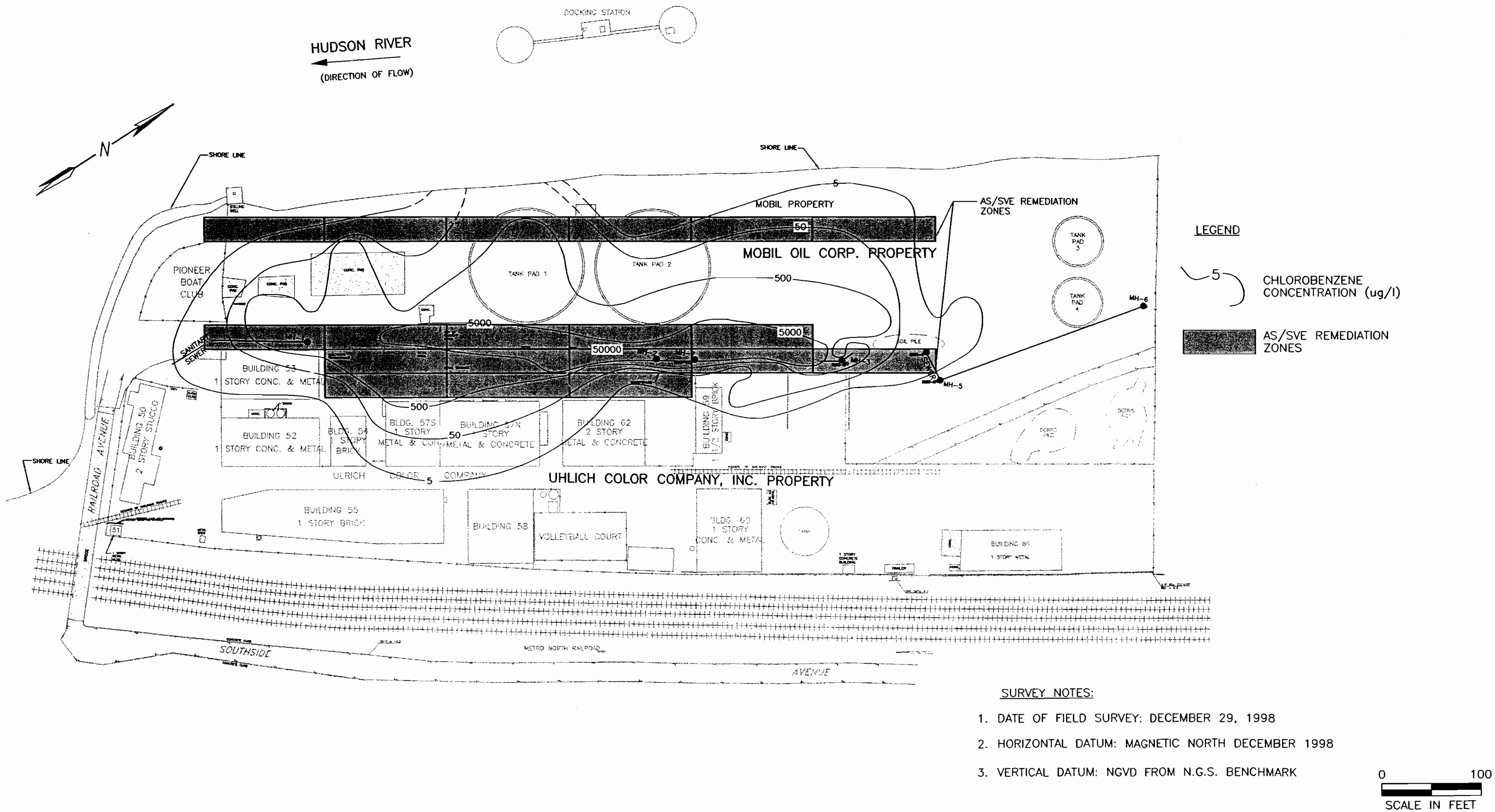
Similar to no action for the soil alternatives, this alternative provides no active remediation of the groundwater and relies solely on natural attenuation. The "no action" alternative will also include monitoring of groundwater for a 30-year period. The monitoring network would consist of sampling two existing upgradient and six existing downgradient wells quarterly for the first 5 years, semiannually for the next 5 years and annually for the remaining 20 years. Based on the results of the monitoring, the number of wells sampled during each event may be modified over time.

4.1.2.2 - Alternative G2 - Air Sparging with Soil Vapor Extraction and Long-Term Groundwater Monitoring

Air sparging (AS) and soil vapor extraction (SVE) wells will be installed along the sewer line to address the highly contaminated subsurface soil and underlying groundwater contamination in the area of the sewer line, and downgradient of the chlorobenzene plume at the western edge of the site on the Mobil property to remediate the volatile organic contamination in the groundwater, which is primarily chlorobenzene. Air sparging will involve the injection of air under pressure into the saturated zone to volatilize groundwater contaminants. Volatilized vapors that migrate into the vadose (unsaturated) zone will be extracted by the SVE system. Extraction/control of vapors is particularly of importance in the vicinity of the buildings on the Uhlich property. A schematic of an air sparging and SVE layout is presented on Figure 4-1.

Due to the heterogeneous nature of the fill material and the potential for short circuiting of air through the soil, the radius of influence for the SVE wells is assumed to be small (15 feet). Based on the radius of influence and the area of the plume, the AS/SVE system will be constructed in zones. Each zone will include one 150-foot horizontal SVE well and six sparge points. The air sparging points will be completed to approximately 15 feet below grade or just above the clay layer with 2 feet of screen. For development of this alternative, it is estimated that nineteen zones will be installed on-site (see Figure 4-1). Due to difficulties with installation of AS/SVE systems beneath active buildings and the difficulties with controlling vapor migration beneath active buildings, the AS/SVE system is not proposed to be installed beneath any active on-site buildings. Once the source area is remediated, it is anticipated that contamination on the Uhlich property upgradient of the sewer line will attenuate or will be captured by the AS/SVE system along the sewer line. Similarly, contamination between the sewer line and the downgradient AS/SVE wells will be captured by the AS/SVE wells along the Hudson River.

In addition to the air sparging and vapor extraction wells, the equipment required for the AS/SVE system includes an oil-free air compressor, liquid/vapor separator, vacuum blower, off-gas granular activated carbon (GAC) treatment unit, piping, and instrumentation and



SURVEY NOTES:

1. DATE OF FIELD SURVEY: DECEMBER 29, 1998
2. HORIZONTAL DATUM: MAGNETIC NORTH DECEMBER 1998
3. VERTICAL DATUM: NGVD FROM N.G.S. BENCHMARK

DIR: 1570 FILE: 1570-28 (T.McC/5-29-00)

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TAPPAN TERMINAL SITE
HASTINGS-ON-HUDSON, NEW YORK

APPROXIMATE LOCATION OF AS/SVE REMEDIATION ZONES

FIGURE 4-1

controls. All equipment will be housed in an on-site building. In addition, groundwater monitoring wells and soil vapor probes will be required to monitor system performance.

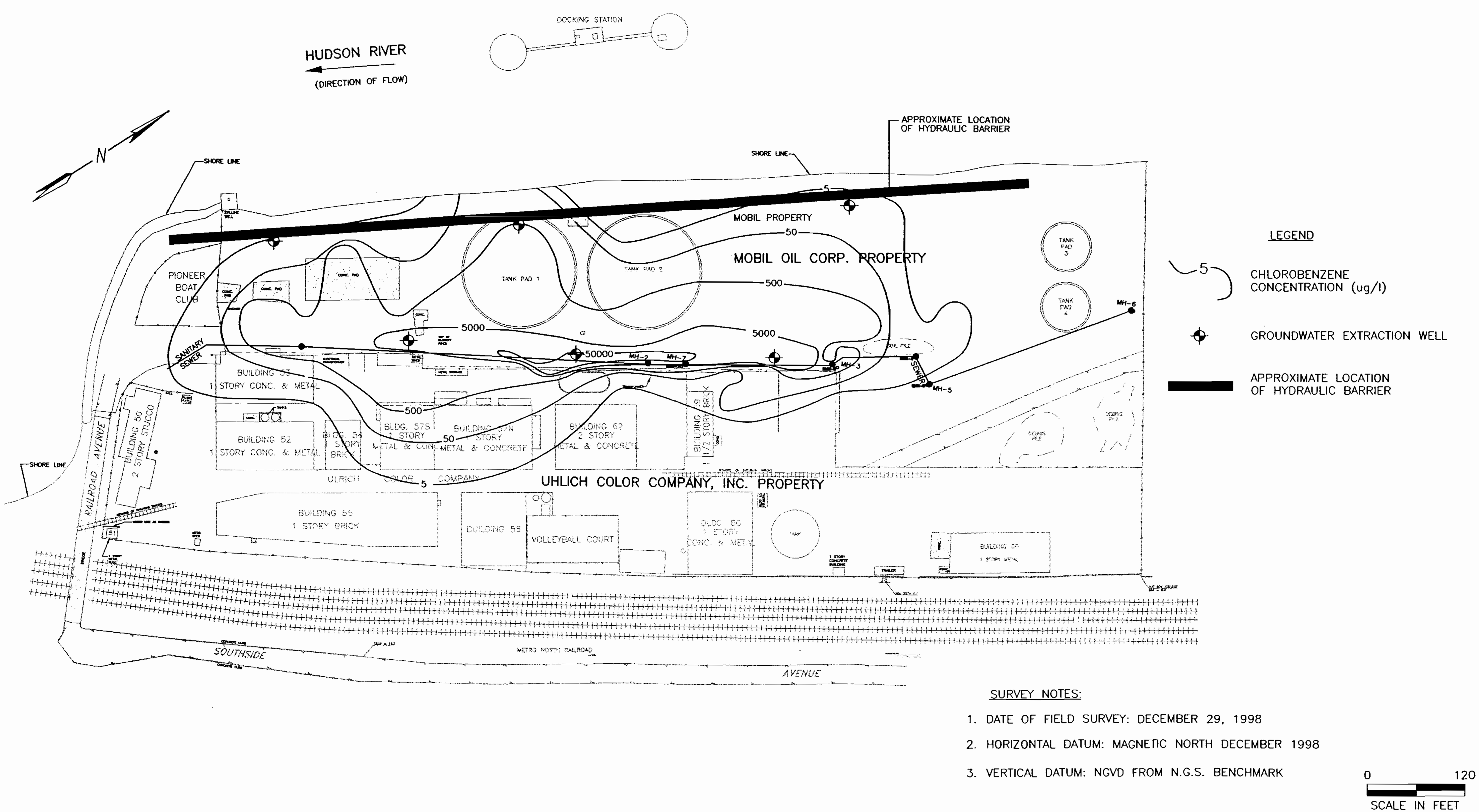
Liquid removed in the liquid/vapor separator may need to be treated and discharged to the POTW or the Hudson River, or removed off site for treatment at a permitted commercial facility.

Placement of a liner over the area being remediated will be necessary to enhance the vacuum effect and vapor capture zone of the SVE system. This cap will also mitigate the continued release of contaminants to groundwater by migration of precipitation through contaminated soil.

Long-term monitoring of groundwater will include sampling of the eight wells discussed for Alternative G1, quarterly for first 5 years, semiannually for the next 5 years and annually for the remaining 5 years.

4.1.2.3- Alternative G3- Hydraulic Barrier, Extraction and Treatment and Discharge to the Hudson River and Long-Term Groundwater Monitoring

In this alternative, a hydraulic barrier in the form of a slurry wall will be installed along 1,000 feet of the western boundary of the site in order to reduce tidal influences on the site from the Hudson River, and pumping and treating river water. This barrier will be installed to a depth of approximately 20 feet keyed into the marine silt/clay underlying the site. Through the use of a two-dimensional groundwater flow model, it was determined that in order to remediate the highly chlorobenzene-contaminated groundwater along the sewer line and mitigate continued migration of the plume to the Hudson River, groundwater will be removed through six groundwater extraction wells pumping a rate of between 10 to 20 gallons per minute (see Figure 4-2). The wells will be screened from the water table to top of the marine gray silt layer. Three extraction wells will be installed along the sewer line to target the chlorobenzene source and three wells will be installed along the leading edge of the plume to collect the remaining contaminated groundwater. Although the spacing of the three wells along the



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APPROXIMATE LOCATION OF GROUNDWATER EXTRACTION WELLS AND HYDRAULIC BARRIER

FIGURE 4-2

leading edge of the plume appears large, the slurry wall will divert water to the south and cause effective extraction by the wells.

The extracted groundwater will be treated for contaminants that exceed Class SB surface water quality standards in order to discharge treated water directly to the Hudson River. Contaminants in groundwater that currently exceed the surface water standards are VOCs, including benzene, chlorobenzene, methylene chloride, toluene, total xylenes, trichloroethene, tetrachloroethene and ethylbenzene; SVOCs, including 1,2-dichlorobenzene, 1,3 dichlorobenzene, 1,4-dichlorobenzene and naphthalene; pesticides, including 4,4'-DDD; and metals, including cadmium, copper, lead and zinc. In addition, pretreatment of groundwater will be required for the removal of iron and manganese prior to treatment for VOC removal in order to prevent fouling of the air stripping system and ensure effective operation of the remediation system. Based on experience, the treatment processes selected to address these contaminants as part of this alternative are the following in sequence from influent to effluent: aeration tank, rapid mix/coagulation/plate settler, aeration tower and granular activated carbon. Off-gas from the aeration tank and tower will be treated with a thermal oxidizer.

Long-term monitoring of groundwater will include monitoring the eight wells discussed for Alternative G1 with sampling the wells four times per year for the first 10 years, two times per year for the next 10 years and one time per year for the next 10 years.

4.1.2.4 - Alternative G4 – In-situ Chemical Oxidation with Long-Term Groundwater Monitoring

In-situ chemical oxidation is a potentially viable alternative for the reduction of chlorobenzene in groundwater at the site. However, since this is still a developing technology and is dependant on site-specific conditions, it is likely that a bench-scale treatability study and a pilot-scale study will be required prior to selection as the preferred remedy and determination of the number and location of treatment points required for full-scale remediation. Information has been obtained from vendors experienced in performing this form of remediation and based on this information, the following remediation alternative has been developed in order to evaluate this technology further. It should be noted that this remedial alternative will likely require modification following the results of both bench-scale and pilot-scale studies.

In-situ chemical oxidation injection points will be installed on-site to treat the chlorobenzene-contaminated groundwater. Oxidizers, catalysts, viscosity enhancers and mobility control agents will be injected into the groundwater points to reduce the levels of chlorobenzene.

Since all work will be completed in situ, there will be no above ground treatment equipment required; however, additional sampling of the groundwater within the treatment zone during the treatment process would be required in order to evaluate the effectiveness of the treatment process.

Following treatment, continued groundwater monitoring would be required to evaluate the processes effectiveness over the long term. Long-term monitoring will be completed as discussed for Alternative G2.

Provided below is the preliminary evaluation of both the soil and groundwater alternatives for effectiveness, implementability and relative cost.

4.2 Evaluation of Soil Remediation Alternatives

4.2.1 Alternative S1

Effectiveness

Alternative S1 (No Action) would not meet any of the three remedial action objectives that pertain to soil which have been established for the Tappan Terminal Site as discussed in Section 1.4 of this document, since no physical remedial action will be undertaken. This alternative will not be protective of human health and the environment, will not eliminate potential exposure to contaminated soil and will not mitigate the migration of precipitation through contaminated soil and continued to contamination of groundwater. This alternative relies solely on natural attenuation which would likely take many decades to be effective. As a result, this alternative is not effective.

Implementability

This alternative is readily implementable physically; however, since no action does not mitigate the potential for contact with contaminated soil and contamination of groundwater, it is not implementable from a regulatory perspective.

Cost

There is no cost associated with Alternative S1.

4.2.2 Alternative S2

Effectiveness

Placement of institutional controls, Alternative S2, on the site without combining institutional controls with any other technology, would not meet any of the three remedial action objectives of the site. Fencing and signs warning of contamination would discourage, but not eliminate access to the site by trespassers. Therefore, it would not be protective of human health and the environment through elimination of direct exposure with contaminated soil. In addition, it would not mitigate migration of precipitation through contaminated soil and contamination of groundwater.

Implementability

This alternative maybe implementable if the property owners and local agencies agree to put deed and zoning restrictions in place and agree to enforce such restrictions. However, because of the uncertainty in following these land use restrictions in the long term and potential contact with soil and continued contamination of groundwater, it likely would not be acceptable to the regulatory agencies.

Cost

The cost for Alternative S2 is low. The cost will not include any active remediation, but would include installation and maintenance of a fence and warning signs. The cost of this alternative would be significantly lower than the remaining alternatives discussed below.

4.2.3 Alternative S3

Effectiveness

Placement of a Part 360 cap over the Mobil property and asphalt pavement and buildings on the Uhlich property, Alternative S3, will meet all three of the remedial action objectives for soil that have been developed for the site and would be more effective than a soil cover, discussed below. This alternative will be protective of human health and the environment through elimination of contact with contaminated soils and will also mitigate the migration of precipitation through contaminated soil and contamination of groundwater. Construction of a Part 360 and pavement cap is a proven, effective remedial technology.

Implementability

All ~~of the~~ necessary labor, equipment, materials and supplies for placement of a Part 360 cap and pavement are readily available, and the caps are fairly easy to construct. Placement of the Part 360 cap on the Mobil property would increase the height in areas of the Mobil property by as much as 8 to 10 feet. Potential difficulties could occur with surface runoff and drainage controls would need to be addressed as part of this alternative in order to prevent flooding on the site.

Cost

The cost for Alternative S3 is moderate. Although construction of a Part 360 cap is costly as compared to soil cover (approximately $150,000 to $200,000 an acre), no soil will need to be disposed off-site, and therefore, the cost of this alternative would not be as high as Alternatives S5 and S6 discussed below.

4.2.4 Alternative S4

Effectiveness

Placement of a soil cover on the Mobil property and pavement on the Uhlich property as part of Alternative S4 would meet two of the three remedial action objectives for the site. It would be protective of human health and the environment through elimination of direct exposure with contaminated soil, but it would not eliminate the infiltration of precipitation through contaminated soil and contamination of groundwater. Placement of a soil cover is a limited, effective proven technology for site remediation.

Implementability

All of the necessary labor, equipment, materials and supplies for placement of soil cover and pavement are readily available, and the covers are easy to construct. Placement of soil cover on the Mobil property would increase the height of the Mobil property by 2 feet. Increasing the elevation of the Mobil property by 2 feet may result in the need for surface runoff drainage controls to prevent flooding of the site.

Cost

The cost for Alternative S4 is low to moderate. No soil will need to be disposed off-site and clean soil and asphalt are readily available. The cost of this alternative would be significantly lower than the Alternatives S5 and S6, and also less than Alternative S3.

4.2.5 Alternative S5

Effectiveness

Alternative S5, hot spot excavation and off-site disposal (Mobil and Uhlich property), soil cover (Mobil property) and pavement cap (Uhlich property) will meet two of the three remedial action objectives that have been established for the site. This alternative will be protective of human health and the environment through the elimination of exposure to contaminated soil, but will not fully mitigate contamination of groundwater. Since only highly contaminated soil, defined as the "hot spot" area, will be removed, precipitation will still infiltrate through the remaining contaminated soil on-site and will continue to impact groundwater; however, to a significantly lesser degree. Excavation and off-site disposal combined with placement of a soil cover on the Mobil property and pavement on the Uhlich property is a limited, effective and proven technology for site remediation.

Implementability

Excavation of the hot spot area of contaminated soil and placement of a soil cover and pavement is readily implementable. All necessary labor, equipment, materials and supplies are readily available, and is fairly easy to perform. Placement of the soil cover in areas of exposed soil will increase the elevation of the site in these areas. This may cause surface drainage difficulties that would need to be addressed in order not to cause flooding of the site. In addition, controls may be required to mitigate off-site migration of organic vapors during excavation.

Cost

The cost of Alternative S5 is moderate to high. Cost for transportation and off-site disposal of the contaminated soil is the most significant cost. However, since the volume of soil requiring disposal is substantially lower than that for Alternative S6, the cost for this alternative is less as compared to S6.

4.2.6 Alternative S6

Effectiveness

Alternative S6, partial excavation and off-site disposal (Mobil property), hot spot excavation and off-site disposal (Uhlich property) and placement of a pavement cap, will meet the three remedial action objectives for the site. This alternative will be protective of human health and the environment, and will eliminate the potential for exposure to the contaminated soil on the Mobil property. In addition, precipitation will not infiltrate through contaminated soil and will not adversely impact groundwater. Excavation and off-site disposal is an effective and proven technology for site remediation.

Implementability

Excavation of unsaturated contaminated soil to a shallow depth of approximately 5 feet, to the water table, is readily performed. All necessary labor, equipment, materials and supplies are readily available. Potential difficulties may arise with transportation of the contaminated soil off-site and clean soil on-site. A significant number of trucks would be needed to transport the contaminated material off-site and clean backfill to the site. Systems to control air emissions, such as temporary structures with vapor controls, covers, dust suppressants, etc., may be required during construction.

Cost

The cost of Alternative S6 is high. Off-site transportation and disposal of the contaminated soil (approximately $50/ton for a total of $4 million) is the most significant cost of this alternative.

4.3 Evaluation of Groundwater Remedial Alternatives

4.3.1 Alternative G1

Effectiveness

Alternative G1 would not meet any of the remedial action alternatives that pertain to groundwater for the site. Since this alternative relies solely on natural attenuation of contamination, it would not be protective of human health and the environment due to the potential for contact with the groundwater and the continued migration of contaminated groundwater to the Hudson River into the foreseeable future.

Implementability

This alternative is readily implementable physically; however, since no action does not mitigate the potential for migration of contaminated groundwater off-site to the Hudson River, it is not implementable from a regulatory perspective.

Cost

The cost associated with this alternative includes the cost for long term groundwater monitoring. The cost for long-term groundwater monitoring would be significantly lower than the alternatives discussed below.

4.3.2 Alternative G2

Effectiveness

Alternative G2 would not completely meet the remedial action alternatives that pertain to groundwater for the site. Although predesign testing would be required to evaluate an actual radius of influence for the air sparging/soil vapor extraction system, this alternative should be effective in reducing VOC contaminant levels to below groundwater standards and mitigate continued migration of VOC-contaminated groundwater to the Hudson River. This alternative would not reduce elevated levels of metals and may not be effective in reducing elevated levels of SVOC contaminants to below standards/guidelines. Although the actual reduction in chlorobenzene by air sparging/soil vapor extraction cannot be determined at this time, it is likely that reduction would be significant enough to mitigate any potential risk to construction workers.

Underground structures, such as bulkheads that may have been installed during filling of the site, may reduce effectiveness during operation of the system. Heterogeneity of the subsurface can cause channeling and blockage of air which would reduce the effectiveness of the system.

Implementability

Although difficulties may be encountered during installation of the air sparging and SVE wells due to subsurface obstructions, since all necessary equipment and materials for the system are readily available, implementation of this alternative would not be prohibitively difficult.

Cost

The cost for this alternative would be comparatively moderate. Due to the small radius of influence expected in the fill material and shallow depth of the wells, a large number of wells would be required to remediate the site. The number of wells and piping to connect the wells to the treatment system dictates the sizing of the blower and associated treatment system, which for this alternative would require a large blower. However, the cost for the AS/SVE system would be less than the cost for Alternative G3.

4.3.3 Alternative G3

Effectiveness

This alternative would meet the remedial action objectives established for groundwater for the site. Use of the slurry wall and extraction wells would mitigate contact with, and migration of, contaminated groundwater to the Hudson River and would therefore protect public health and the environment. Water discharged to the Hudson River would be treated for VOCs, SVOCs, pesticides and metals to levels below the Class SB surface water standards established for the protection of water quality in the river.

Implementability

All of the necessary labor, equipment, materials and supplies for construction of a hydraulic barrier, extraction wells and treatment system are readily available. Potential problems with encountering subsurface obstructions during installation of the slurry wall or extraction wells may cause difficulties during implementation; however, implementation of this alternative would also not be prohibitively difficult.

Cost

The cost for Alternative G3 is high. Treatment for SVOCs, pesticides and metals in addition to VOCs, and disposal of sludge residuals at an off-site permitted facility results in cost for this alternative above Alternatives G2 and G4, which only address treatment for VOCs.

4.3.4 Alternative G4

Effectiveness

Alternative G4 would not completely meet the two remedial action alternatives that pertain to groundwater for the site. A bench-scale test would need to be performed to address treatment effectiveness and a pilot-scale would be required to determine treatment material quantities, efficiency, radial extent of treatment, injection mechanism and site-specific chemical formulation. This alternative should be effective in reducing VOC-contaminant levels; however, the pilot study would evaluate the potential for this technology to reduce levels of contaminants to below groundwater standards and mitigate continued migration of VOC-contaminated groundwater to the Hudson River. As stated above for Alternative G2, this alternative would not reduce levels of metals and may not reduce levels of SVOCs to below groundwater standards, but should reduce chlorobenzene levels to mitigate any potential risk to construction workers. Several factors can affect the efficiency of the treatment system. The total organic carbon content of the soil and waste material in the soil can impact the amount of oxidant required. Similar to air sparging, subsurface obstructions can impact radial effectiveness of the oxidant.

Implementability

This alternative would be readily implemented. Since it is an in-situ technology and does not require piping to connect the injection points, limited disruption of the surface is required. Also, it does not require aboveground equipment, such as compressors and/or blowers associated with an air sparging/soil vapor extraction system. All of the necessary labor, equipment, materials and supplies are available.

Cost

The cost for this alternative would likely be low. The results of a pilot study would provide additional detail on the volume of oxidant and number of injection points required, as well as the total cost for remediation. However, the overall cost would likely be lower than Alternatives G2 and G3.

4.4 Summary of Evaluation of Alternatives

Provided in Tables 4-1 and 4-2 are summaries of the preliminary evaluation of the soil and groundwater remedial alternatives developed for the Tappan Terminal Site.

Table 4-1

SUMMARY OF PRELIMINARY COMPARATIVE EVALUATION OF SOIL REMEDIAL ALTERNATIVES
TAPPAN TERMINAL SITE

Remedial Alternative		Effectiveness	Ease of Implementation	Relative Cost	Retained
Alternative S1	No Action	Low	High (however, will likely not be acceptable to regulatory agencies or the public)	Low	Yes (required by feasibility study guidance)
Alternative S2	Institutional Controls	Low	High (however, will also likely not be acceptable to regulatory agencies or the public)	Low	Yes
Alternative S3	Part 360 Cap (Mobil property) and Pavement Cap (Uhlich property)	Moderate to High	Low (difficulties with height of Part 360 cap on Mobil property, significant truck traffic and storm water runoff)	Moderate to High	Yes
Alternative S4	Soil Cover (Mobil property) and Pavement Cap (Uhlich property)	Moderate	Moderate (may have difficulties with storm water runoff and truck traffic)	Low to Moderate	Yes
Alternative S5	"Hot Spot" Excavation and Off-site Disposal (Mobil and Uhlich properties), Soil Cover (Mobil property) and Pavement Cap (Uhlich property)	High	Moderate (disruptions during excavation of contaminated soil and truck traffic)	Moderate	Yes
Alternative S6	Partial Excavation and Off-site Disposal (Mobil property), Hot Spot Excavation and Off-site Disposal (Uhlich property) and Pavement Cap (Uhlich property)	High	Low to moderate (disruptions during excavation of contaminated soil and truck traffic)	High	Yes

Table 4-2

SUMMARY OF PRELIMINARY COMPARATIVE EVALUATION OF GROUNDWATER REMEDIAL ALTERNATIVES
TAPPAN TERMINAL SITE

Remedial Alternative		Effectiveness	Ease of Implementation	Relative Cost	Retained
Alternative G1	No Action and Long-term Monitoring	Low	High (however, will likely not be acceptable to regulatory agencies or the public)	Low	Yes (required by feasibility study guidance)
Alternative G2	Air Sparging with Soil Vapor Extraction and Long-term Monitoring	Moderate to High	Moderate(may encounter difficulties with subsurface obstructions during installation and operation due to decreased radius of influence)	Moderate	Yes
Alternative G3	Hydraulic Barrier, Extraction and Treatment and Discharge to the Hudson River	High	Moderate (may encounter difficulties with subsurface obstructions during installation of the slurry wall and will require significant aboveground treatment systems)	High	Yes
Alternative G4	In-situ Chemical Oxidation and Long-term Monitoring	Moderate*	Moderate to high (may encounter difficulties with subsurface obstructions and small radius of influence)	Low to Moderate	Yes

*Needs to be evaluated in site-specific pilot test and effectiveness determined/confirmed.

With regard to selection of alternatives to be evaluated further in detail in order to select a remedial plan for the site, all of the remedial alternatives discussed above (Alternatives S2 through S6 for soil and Alternatives G2 through G4 for groundwater) are considered viable and will be evaluated further in detail, together with the no action alternatives (Alternatives S1 and G1) as required by the guidance.

Section 5

5.0 DETAILED ANALYSIS OF ALTERNATIVES

Based on the preliminary evaluation of the remedial alternatives selected for the Tappan Terminal Site in Section 4.0, all of the soil and groundwater alternatives for the site (six soil and four groundwater) have been retained for detailed analysis. As discussed in Section 4.4, soil and groundwater alternatives will continue to be evaluated separately in order to be able to develop the best overall preferred remediation plan for the site. The following summarizes the soil and groundwater alternatives to be evaluated in detail in this section:

Soil Alternatives

S1 – No Action
S2 – Institutional Controls (fencing for the Mobil property and land use restrictions for both Mobil and Uhlich properties)
S3 – Part 360 Cap (Mobil property) and Pavement Cap (Uhlich property)
S4 – Soil Cover (Mobil property) and Pavement Cap (Uhlich property)
S5 –Hot Spot Excavation and Off-site Disposal (both Mobil and Uhlich properties), Soil Cover (Mobil property) and Pavement Cap (Uhlich property)
S6 – Partial Excavation and Off-site Disposal (Mobil property) Hot Spot Excavation and Off-site Disposal (Uhlich property), and Pavement Cap (Uhlich property)

Groundwater Alternatives

G1 – No Action with Long-Term Groundwater Monitoring
G2 – Air Sparging and Soil Vapor Extraction with Long-Term Groundwater Monitoring
G3 – Hydraulic Barrier, Extraction and Treatment, and Discharge to the Hudson River with Long-Term Groundwater Monitoring
G4 – In-situ Chemical Oxidation with Long-Term Groundwater Monitoring

Provided below is a detailed evaluation of the each of soil and groundwater alternatives. Based on this detailed evaluation, a remedial plan for the site will be selected for regulatory and public comment. In accordance with federal (USEPA) and New York State guidance, the following feasibility study evaluation criteria will be addressed in the detailed evaluation of alternatives.

- Threshold Criteria
  - Protection of human health and the environment
  - Compliance with applicable regulatory standards, criteria and guidelines/ARARs

- Balancing Criteria
  - Short-term impacts and effectiveness
  - Long-term effectiveness and permanence
  - Reduction in toxicity, mobility and/or volume of contamination
  - Implementability
  - Cost

- Modifying Criteria
  - Community acceptance

A detailed description of each of these criteria is provided in Section 1.4 of this document.

Provided below is a comparative analysis of the remedial alternatives to each of the detailed evaluation criteria presented above.

5.1 Soil Remediation Alternatives

5.1.1 Overall Protection of Human Health and the Environment

Alternative S1 will not be protective of human health and the environment since natural attenuation of contaminants in the soil will not be effective in the 30-year remediation period.

Alternative S2 will also not be protective of human health and the environment in and of itself. Although existing fencing would be maintained and new fencing will be installed, trespassers may still be able to access the site and come into contact with contaminated soil. In addition, precipitation will continue to infiltrate through the contaminated soil and impact groundwater. Although land use and activity restrictions can be put in place, long-term implementation of these restrictions cannot be guaranteed.

Placement of a Part 360 cap over the Mobil property and a pavement cap over exposed areas on the Uhlich property (Alternative S3), in addition to installation of and maintenance of fencing around the site and land use and activity restrictions, will be protective of human health and the environment through elimination of the potential for contact with contaminated soil. The Part 360 cap and pavement cap will also mitigate migration of precipitation through contaminated soil and impacts on groundwater.

Alternative S4, which involves placement of a soil cover over the Mobil property and placement of a pavement cap over exposed areas of the Uhlich property, would be protective of human health through mitigation of contact with contaminated soil. However, the soil cover will not prevent infiltration of precipitation through contaminated soil and impacts on groundwater on the Mobil property.

Hot spot excavation and off-site disposal of the contaminated soil along the sewer line, placement of a soil cover over the Mobil property and placement of a pavement cap over exposed areas on the Uhlich property (Alternative S5), would provide protection of human health as it relates to contact with contaminated soil. Removal of the highly contaminated chlorobenzene soil from the vadose zone would mitigate contact with this soil by construction workers. Although precipitation will continue to migrate through some of the contaminated soil on the Mobil property, it will not migrate through the chlorobenzene contaminated soil which will be removed. Since chlorobenzene is the main contaminant of concern in groundwater at the site, this alternative will mitigate the primary impact to groundwater.

Alternative S6, which includes excavation and off-site disposal of all contaminated soil above the water table on the Mobil property, excavation and off-site disposal of contaminated soil along the sewer line on the Uhlich property and placement of a pavement cap over exposed soil on the Uhlich property, will be the most protective alternative since the majority of the contaminated soil which could be accessed or could cause impacts to groundwater will be removed from the site or capped.

Based on this comparative analysis, Alternative S6 would be the most protective of human health and the environment followed by Alternatives S5, S3, S4, S2 and S1, respectively. Although neither Alternatives S1 or S2 are protective of human health and the environment, placement of institutional controls may limit access to the contaminated soil. In addition, although placement of any cover would reduce access to contaminated soil, placement of a Part 360 cap and pavement would also mitigate impacts to groundwater.

5.1.2 Compliance with Standards, Criteria and Guidelines

Alternative S1 will not be compliant with any of the standards, criteria and guidelines (SCGs), and applicable or relevant and appropriate requirements (ARARs) established for the site as described in Section 1.4. Alternative S2 which provides institutional controls, including fencing and activity and use limitations, may limit contact with contaminated soil.

Alternative S3 will be basically compliant with the SCGs and ARARs established for the site. The majority of exposed contaminated soil will be capped in accordance with New York State Part 360 regulations. Remaining contaminated soil will be covered with a pavement cap. Although soil in excess of the NYSDEC Recommended Soil Cleanup Objectives (RSCOs) will remain in place, it will not be readily accessible.

Alternative S4 will not be completely compliant with the SCGs and ARARs established for the site. Similar to Alternative S3, although soil in excess of the RSCOs will not be readily accessible, groundwater will continue to be impacted by the migration of precipitation through contaminated soil on the Mobil property. The pavement cap on the Uhlich property would limit direct contact and infiltration of precipitation.

Alternative S5, will remove some of the soil in excess of the RSCOs above the water table, will cover the Mobil property with 2 feet of clean soil and cap exposed soil on the Uhlich property with pavement. During the excavation of the contaminated soil, engineering controls will be implemented in order to prevent release of contaminants to the Hudson River and surrounding properties, as well as contravention of air emissions requirements. Off-site transportation and disposal of contaminated soil will comply with all SCGs, including any vapor and dust control/monitoring requirements, transportation regulations and land disposal restrictions. Therefore, although this alternative will not be completely compliant with the chemical-specific SCGs/ARARs, it should be compliant with all other SCGs/ARARs for the site.

Alternative S6 will be the most compliant in meeting the SCGs and ARARs for the site since a majority of the unsaturated, accessible soil in excess of the RSCOs will be removed off-site. Remaining accessible soil on the Uhlich property will be paved. As stated for Alternative S5, all necessary engineering controls, monitoring requirements, transportation regulations and land disposal restrictions will be implemented for this alternative.

Based on this comparative analysis, Alternative S6 would be more compliant with SCGs/ARARs than Alternative S5 since a majority of the soil in excess of the RSCOs will be removed off-site. Alternative S3 will be more compliant with the SCGs and ARARs than Alternative S4 since it also reduces infiltration of precipitation through contaminated soil. Alternative S2 limits access to the site and contaminated soil, therefore, Alternative S2 would be more compliant than Alternative S1.

5.1.3 Short-term Impacts and Effectiveness

Alternatives S1 and S2 will not have any short-term construction related impacts and can be fully implemented immediately; however, while fencing and activity and use limitations (Alternative 2) may be more effective than no action (Alternative 1) in the short term in mitigating human contact with contaminated soil, Alternative 2 will not be effective in preventing contact with contaminated soil by terrestrial organisms and infiltration of precipitation through contaminated soil.

Once a Record of Decision has been issued, Alternative S3, installation of a Part 360 cap (Mobil property) and pavement (Uhlich property), will take approximately 18 to 24 months to be implemented, including design and construction. This alternative will be effective in the short term in reducing the potential for direct contact with contaminated soil and the potential for infiltration of precipitation through contaminated soil. All work associated with construction of the cap can be performed without adverse impacts to human health, including on-site workers and the surrounding community, as well as the environment, with proper engineering, and health and safety controls. Due to the volumes of material that will be needed to be brought on-site in order to meet the required 4 percent grade for the cap (over 36,000 cy) significant truck traffic will occur during implementation of this alternative unless cap materials, including contour grading soil, can be delivered to the site by water/barge. Any contaminated soil that may be generated during construction will be properly and safely handled, and placed on-site under the cap, or off-site if necessary.

Alternative S4 (soil cover [Mobil property] and pavement cap [Uhlich property]) can be implemented within 9 to 12 months after selection of this alternative and issuance of a Record of Decision, and will be immediately effective in the short term in reducing the potential for direct contact with contaminated soil. As discussed previously, although placement of pavement on the Uhlich property will be effective in reducing infiltration of precipitation through contaminated soil and impacts on groundwater, placement of soil cover on the Mobil property will not be effective with regard to mitigation of impacts on groundwater. With proper implementation of a construction health and safety plan and construction quality assurance plan, there will be no adverse impacts on human health and the environment during construction of the cover. Over 19,000 cy of material will need to be brought on-site for use in construction of the soil cover on the Mobil property. Other than an increase in truck traffic, no other significant disruption to the surrounding community is expected with implementation of this alternative.

Alternative S5, hot spot excavation, and soil cover (Mobil property) and pavement cap (Uhlich property), can be implemented within 12 to 18 months and will be immediately effective in the short term with regard to mitigating the potential for direct contact with contaminated soil. It will also be partially effective in reducing the infiltration of precipitation through contaminated soil. Short-term impacts can occur due to dust generation from the excavation of the soil; however, with proper implementation of a health and safety plan and engineering controls, adverse impacts to human health will be minimized, including potential impacts to off-site receptors and the environment during transportation of contaminated soil off-site.

Approximately 7,000 cy of material will need to be transported off-site, and 24,000 cy of material will need to be transported on-site for the 2-foot soil cover and backfill. This may result in an increase in significant truck traffic in the vicinity of the site.

Excavation and off-site disposal of all soil in the vadose zone on the Mobil property, excavation and off-site disposal of contaminated soil along the sewer line on the Uhlich property and placement of a pavement cap on all exposed soil on the Uhlich property (Alternative S6) will take approximately 18 to 24 months to complete. It will be effective immediately with regard to both direct contact to soil and mitigation of migration of infiltration through contaminated soil. Short term impacts due to the excavation of over 60,000 cy of material may occur due to dust generation and off-site transportation of contaminated soil, however, as described above, with the appropriate implementation of construction plans and engineering controls, short term impacts should be minimized. Significant truck traffic may occur with this alternative unless the contaminated soil and clean backfill can be removed from/transported to the site by barge.

Based on the above discussion, Alternatives S1 and S2 would have the least short-term impacts followed by Alternative S4, which can be implemented within a shorter period of time, compared to Alternative S3. Alternative S5 would have less short-term impacts than Alternative S6 due to less volume of contaminated soil requiring excavation and less clean soil for backfill, and therefore, less truck traffic.

5.1.4 Long-term Effectiveness and Permanence

Alternatives S1 and S2 will not provide for long-term effectiveness and permanence since remediation of the contaminated soil will not occur, and contaminants will continue to be accessible and released to the environment in significant, unacceptable levels.

Alternative S3 will provide long-term effectiveness and permanence in protecting human health and the environment by isolating and controlling exposure to and release of contaminants from contaminated soil. Placement of a low permeability cap on the Mobil property is considered an effective long-term and permanent remedial action. Although a pavement cap is not as effective/permanent as a Part 360 cap in the long-term, the risk posed by the contaminants that remain on site would be minimal, since the contaminated soil will be isolated from direct exposure, as well as direct contact with precipitation, either under the geomembrane liner (Part 360 cap) or under pavement if properly maintained. This alternative will require inspection and maintenance for the 30-year remediation period. The extended long-term effectiveness and permanence of a Part 360 cap beyond the 30-year period is unknown.

Alternative S4 will provide less long-term effectiveness and permanence than Alternative S3 since placement of a soil cover on the Mobil property is not as effective in the long-term in reducing impacts to groundwater as a Part 360 cap. In addition, unlike the geomembrane cap, the placement of a soil cover is not as effective in mitigating potential for direct contact with contaminated soil.

Alternative S5 provides more long-term effectiveness and permanence by removing the potentially accessible highly contaminated soil above the water table that is also impacting groundwater. Long-term impacts to groundwater and potential contact with contaminated soil will be reduced through implementation of this alternative, which includes hot spot soil excavation and off-site disposal, soil cover (Mobil property) and pavement cap (Uhlich property).

Alternative S6 would be the most effective and permanent in the long-term through the removal of the majority of contaminated soil above the water table that would cause long-term impacts to human health and the environment. Since the contaminated soil is removed off-site, and remaining exposed soil is paved, this alternative would be considered permanent and require a low degree of maintenance over the 30-year remediation period.

Based on this comparative analysis, Alternative S6 is the most effective in the long term for remediation of the soil contamination, requiring little long-term monitoring/maintenance compared to the other alternatives, and providing long-term effectiveness and permanence. Of the remaining alternatives, since Alternative S5 removes the highly contaminated unsaturated soil impacting groundwater and provides a soil and pavement cover, it would be the next most effective and permanent alternative in the long-term, followed by Alternatives S3 and S4, respectively. Since Alternative S2, institutional controls, does limit access to contaminated soil, it would be more effective in the long-term compared to S1, which is no action.

5.1.5 Reduction of Toxicity, Mobility or Volume Through Treatment

Alternatives S1 and S2 will not be effective in reducing the toxicity, mobility or volume of the contaminants in the soil, and as a result, contaminants will continue to be released to and migrate in the environment in significant concentrations.

Alternative S3 will not reduce the toxicity or volume of contaminated soil; however, it will reduce the mobility of contaminants in the soil and impacts on groundwater, not through treatment, but through isolation and mitigation of precipitation through the contaminated soil. Reduction of infiltration of precipitation through contaminated soil will reduce impacts to groundwater, and therefore, will reduce the toxicity and volume of contaminants in groundwater. However, since this alternative will not treat or destroy the contaminants in soil, and the effectiveness of a Part 360 cap beyond 30 years is not known, it is considered potentially reversible.

Similarly, Alternative S4 will not reduce the toxicity or volume of the contaminated soil, but placement of the soil cover on the Mobil property would reduce the mobility of contaminants through the elimination of the potential for surface runoff to the Hudson River or dust migration. In addition, placement of the pavement cap on the exposed soil on the Uhlich property would also mitigate the migration of contaminants to groundwater.

Alternatives S5 and S6 will reduce the toxicity, mobility and volume of contaminated soil on-site through excavation of contaminated soil above the water table and off-site disposal of the contaminated soil. However, since Alternative S6 removes more contaminated soil, it would be more effective than Alternative S5. In addition, removal of contaminated soil from the site will allow these alternatives to be partially irreversible with respect to the site.

Based on the above comparative analysis, Alternative S6, which removes the most contaminated soil from the site, followed by Alternatives S5, S3 and S4, respectively, will be the most effective in reducing the toxicity, mobility and volume of contaminated soil at the site. Alternatives S1 and S2 will be equally ineffective in reducing toxicity, mobility and volume of contaminants in soil at the site.

5.1.6 Implementability

As discussed in Section 4.2, although Alternative S1 is readily implementable physically, it is not implementable from a regulatory perspective. Alternative S2 may be implementable if the property owners and local agencies agree to put land use and activity restrictions in place, and agree to enforce such restrictions. Placement of a fence around the site will not be difficult and can be completed immediately.

All of the necessary labor, equipment, materials and supplies for implementation of Alternative S3, placement of the Part 360 cap (Mobil property) and pavement cap (Uhlich property), and Alternative S4, placement of a soil cover (Mobil property) and pavement cap (Uhlich property), are readily available. Increasing the height of the central portion of the Mobil property (8 to 10 feet with the Part 360 cap and 2 feet for the soil cover) may cause potential problems with surface runoff, and therefore, drainage controls would need to be addressed. Materials and supplies needed for installation of the Part 360 cap, as well as the construction techniques for installation, are more specialized than those required for the soil cover. Placement of the Part 360 cap could limit future site use and redevelopment due to the height of the cap, as well as maintaining the integrity of the geomembrane. If use of a 2 percent grade is approved, the height of the cap would be reduced, thereby increasing the options for future site use.

Excavation of contaminated soil above the water table associated with Alternatives S5 and S6 may require emissions controls to mitigate off-site migration of organic vapors and dust. As stated above, drainage controls with placement of the 2-foot soil cover associated with Alternative S5 would need to be addressed. With the exception of the time required to implement this alternative, implementation of either Alternative S5 or S6 would not impact future site use.

No delays regarding implementation of any of the alternatives is expected. Coordination with the appropriate regulatory agencies would be necessary for all of the alternatives, but is not expected to impact implementation.

Alternative S1 is the easiest alternative to implement followed by Alternative S2. Alternative S4 is easier to implement than Alternative S5 since it does not require excavation of contaminated soil. Due to the complexity of the materials and supplies and construction techniques, in addition to the need for storm water drainage controls and long-term maintenance required, Alternative S3 will be more difficult to implement than Alternative S6.

5.1.7 Cost

The estimated capital costs, and long-term (30-year) operation and maintenance (O&M) and monitoring present worth costs associated with the soil alternatives are presented in Table 5-1. A detailed breakdown of each estimate is provided in Appendix B.

The following assumptions were utilized in the preparation of the cost estimates:

- Costs are rounded to the nearest thousand dollars.
- All site work costs (e.g., excavation, backfill, etc.) were estimated using Means Site Work Cost Data for 1999, experience in construction and adjusted for hazardous site remediation, and discussion with remedial contractors and disposal facilities.

As can be seen in Table 5-1, S1 is the lease costly alternative, followed by S2, S4, S5, S3 and S6.

Table 5-1

SOIL ALTERNATIVES COST SUMMARY

Alternative	Estimated Capital Cost	Estimated Contingency and Engineering Fees	Present Worth of Annual Operating Maintenance and Monitoring Costs (30 years)	Total Estimated Costs Based on Present Worth
S1	$0	$0	$0	$0
S2	$23,000	$8,000	$34,000	$65,000
S3	$2,176,000	$652,000	$351,000	$3,179,000
S4	$1,158,000	$348,000	$320,000	$1,826,000
S5	$1,457,000	$438,000	$320,000	$2,215,000
S6	$6,039,000	$1,510,000	$145,000	$7,694,000

5.1.8 Community Acceptance

Alternative S1, since it will not provide for effective remediation of contaminated soil and mitigation of impacts to groundwater, it is not expected that this alternative will be acceptable to the community. Alternative S2 provides some protection against direct contact to contaminated soil, and therefore, likely will be more acceptable to the community as compared to Alternative S1.

The remaining alternatives would all likely be acceptable to the community; however, since contaminated soil is being removed off-site in Alternatives S5 and S6, these alternatives may be more acceptable to the community as compared to Alternatives S3 and S4.

Therefore, Alternative S6 would likely be the most acceptable to the community since it is the most permanent remedy for the site, followed by Alternatives S5, S3 and S4, respectively, since a Part 360 cap is more permanent than a soil cover. Alternatives S2 and S1 would be the least acceptable alternatives, respectively.

A summary of the comparative analysis of the soil alternatives is provided in Table 5-2.

5.2 Groundwater Remediation Alternatives

5.2.1 Overall Protection of Human Health and the Environment

Alternative G1, no action with long term groundwater monitoring, will not be protective of human health and the environment since natural attenuation of the groundwater will not be effective in the 30-year planning period. Potential exposure to groundwater contaminated with chlorobenzene by an on-site construction worker was determined to be a risk in the Baseline Human Health Risk Assessment for the site. Potential environmental impacts include migration of contaminated groundwater to the Hudson River.

Table 5-2

SUMMARY OF SOIL REMEDIAL ALTERNATIVE COMPARATIVE ANALYSIS
TAPPAN TERMINAL SITE

Evaluation Criteria	Alternative S1 – No Action	Alternative S2 – Institutional Controls	Alternative S3 - Part 360 Cap (Mobil Property) and Pavement Cap (Uhlich Property)	Alternative S4 – Soil Cover (Mobil Property) and Pavement Cap (Uhlich Property)	Alternative S5 –Hot Spot Excavation* Off-Site Disposal (Mobil and Uhlich properties), Soil Cover (Mobil Property) and Pavement Cap (Uhlich Property)	Alternative S6 – Partial Excavation* and Off-Site Disposal (Mobil Property), Hot Spot Excavation and Off-site Disposal (Uhlich Property)and Pavement Cap (Uhlich Property)
Protection of Human Health and the Environment	6	5	3	4	2	1
Compliance with SCGs/ARARs	6	5	3	4	2	1
Short-term Impacts and Effectiveness	2	1	4	3	5	6
Long-term Effectiveness and Permanence	6	5	3	4	2	1
Reduction of Toxicity, Mobility or Volume through Treatment	6	5	3	4	2	1
Implementability	1	2	6	3	4	5
Cost	1 ($0)	2 ($65,000)	5 ($3,179,000)	3 ($1,826,000)	4 ($2,215,000)	6 ($7,694,000)
Community Acceptance	6	5	3	4	2	1
Total	34	30	30	29	23	22

Note: Lowest numerical score is highest ranking.
* Above water table.

Alternative G2, air sparging (AS) with soil vapor extraction (SVE) and groundwater monitoring, will likely be effective in reducing the levels of volatile organic compound (VOC) contamination in groundwater and soil, and mitigating further migration of VOC contaminated groundwater off-site to the Hudson River. This alternative would not be effective in reducing elevated levels of metals in the groundwater and would likely be only partially effective in reducing elevated levels of semivolatile organic compound (SVOC) contamination through enhanced bioremediation. The effectiveness of an AS/SVE system, and therefore potential overall reduction of contaminants by the system, would need to be evaluated in a pilot study.

As stated above, exposure to groundwater by a construction worker due to the elevated levels of chlorobenzene in the groundwater presents a risk. Although the actual reduction in chlorobenzene by air sparging/soil vapor extraction cannot be determined at this time, it is likely that the reduction would be significant enough to mitigate any potential risk to construction workers. Similarly, it is anticipated that any potential impacts to the environment could be reduced though implementation of this alternative. Soil vapor extraction would also reduce concentrations of VOCs in the vadose zone, which would aid in overall reduction of chlorobenzene in groundwater.

Alternative G3, hydraulic barrier, groundwater extraction and treatment, and groundwater monitoring, is a proven technology that would be protective of human health and the environment since it would treat all contaminants in exceedance of groundwater standards and would mitigate migration of contaminants to the Hudson River.

In-situ chemical oxidation (Alternative G4) is a developing technology that would require a bench scale treatability study, as well as a pilot scale study, to demonstrate the effectiveness of the technology in remediating the contaminants of concern in groundwater at the site. Information provided by vendors indicates that this technology likely would not be applicable to contamination in the vadose zone due to the potential for preferential flow of oxidants through the heterogeneous fill material and the presence of competing organics in the fill. Laboratory and pilot studies would provide information on the percent reduction of contaminants that the system could achieve in the groundwater. This groundwater alternative would need to be combined with a soil remediation alternative (i.e., removal), because without reduction of the chlorobenzene in the vadose zone, this technology would not be effective due to the continued release of chlorobenzene from soil to groundwater.

Chemical oxidation would not be effective at reducing the levels of SVOCs and metals in the groundwater and the percent reduction of VOCs that could be achieved is unknown. Although it is expected that the reduction in levels of chlorobenzene would be sufficiently significant to mitigate potential risks to human health and the environment, the level of reduction may not be as significant as air sparging/soil vapor extraction.

Based on this comparative analysis, Alternative G3 would be the most protective of human health and the environment due to its proven effectiveness and ability to treat SVOCs and metals in addition to VOCs. Alternative G2 would be more protective than Alternative G4 since it is a more proven technology, will reduce levels of chlorobenzene in soil and may be more effective than chemical oxidation. Alternative G1 would not be protective of human health and the environment.

5.2.2 Compliance with Standards, Criteria and Guidelines

Alternative G1, no action, will not be compliant with any of the SCGs established for the site since significant natural attenuation of the groundwater is not expected to occur.

Alternative G2, air sparging with soil vapor extraction, and Alternative G4, in-situ chemical oxidation, will not meet the groundwater standards due to continued exceedances in SVOCs and metals, and may not meet the groundwater standards for VOCs. Air sparging with soil vapor extraction would likely enhance bioremediation at the site, and therefore, may reduce SVOCs in groundwater. These alternatives would meet all other applicable SCGs and ARARs established for the site, including vapor emission requirements.

Alternative G3 will be compliant with all of the SCGs and ARARs established for the site through the treatment of all contaminants in excess of groundwater standards and the use of vapor controls to meet any vapor emission requirements. This alternative would also be required to meet State Pollutant Discharge Elimination System (SPDES) levels for discharge of treated water into the Hudson River.

Based upon the above comparison, Alternative G3 would be the most compliant with the SCGs and ARARs established for the site followed by Alternatives G2 and G4, respectively. Alternative G1 will not be compliant with SCGs/ARARs.

5.2.3 Short-term Impacts and Effectiveness

Alternative G1 will have no short-term impacts and can be implemented immediately. Existing groundwater monitoring wells are expected to be satisfactory for long-term monitoring, and therefore, new wells should not need to be installed. However, this alternative will not be effective in the short-term in preventing the migration of contaminants to the Hudson River or the potential for contact with contaminated groundwater.

Alternative G2, with proper design and installation, will not likely have any short-term impacts and will be effective immediately in reducing the levels of VOCs in groundwater (and soil). This alternative can be implemented within 12 to 18 months of selection of this alternative/Record of Decision. Potential problems may occur with the migration of contaminated vapors outside of the vacuum radius of influence. However, with proper design and installation, difficulties with the release of contaminated vapors can be controlled. Installation of the soil vapor extraction wells will likely require trenching into contaminated soil, and therefore, appropriate measures will be taken to prevent fugitive emissions and runoff, such as dust suppressants, liners and covers.

Alternative G3 will also have no significant short-term impacts and will be effective immediately in mitigating migration of contaminants to the Hudson River and reducing elevated levels of contaminants in groundwater. This alternative can be implemented within 18 to 24 months of the Record of Decision. Construction of the hydraulic barrier may require excavation of contaminated soil, and as stated above, appropriate measures will be taken to prevent fugitive emissions and runoff, such as dust suppressants, liners and covers.

Alternative G4 can be implemented within approximately 9 to 12 months of the Record of Decision, will have no short-term impacts and will be effective immediately in reducing the levels of VOCs in groundwater. Since all work will be completed in-situ at individual locations, there will be no excavation of contaminated soil, and no piping and aboveground construction of treatment facilities. Although this alternative will likely use a potentially hazardous material, such as hydrogen peroxide as the oxidant, appropriate handling and health and safety precautions will reduce the potential hazards associated with using this material.

Based on this comparative analysis, Alternative G1 will have the least short-term impacts followed by Alternative G4, G2 and G3, respectively.

5.2.4 Long-Term Effectiveness and Permanence

Alternative G1, which is no action, will not be effective or permanent in the long-term for remediation of groundwater.

Alternative G2, air sparging with soil vapor extraction, will be effective and permanent in the long-term with respect to VOCs and possibly SVOCs in soil and groundwater.

By hydraulically controlling and treating contaminated groundwater, it is expected that Alternative G3 will be effective and permanent in the long-term. This alternative will reduce levels of VOCs, SVOCs and metals in groundwater, and mitigate migration of these contaminants to the Hudson River. The risks posed by treatment residuals will be minimal or non-existent, since these residuals will be contained and disposed of off-site at a permitted treatment facility.

Since chemical oxidation (Alternative G4) is a developing technology there is not sufficient information regarding the long-term effectiveness or permanence of this alternative. Chemical oxidation likely will not be effective in remediating chlorobenzene in the unsaturated soil, and therefore, will need to be combined with a soil alternative to remediate the chlorobenzene in the vadose zone. If the source of chlorobenzene contamination is remediated in the vadose zone, it is expected that chemical oxidation would be a permanent remedy. The results of a bench scale and pilot study would demonstrate the effectiveness of the technology relative to this site.

In summary, since Alternative G3 would reduce all of the contaminants of concern in the groundwater, it would be more effective in the long term than Alternative G2. Due to its applicability to soil and groundwater, Alternative G2 (air sparging with soil vapor extraction) would be more effective than Alternative G4 (chemical oxidation). Alternative G1, no action, would not be an effective or permanent remedy for the site.

5.2.5 Reduction of Toxicity, Mobility or Volume Through Treatment

Alternative G1 will not be effective in reducing the toxicity, mobility or volume of contaminants in groundwater at the site, since natural attenuation is not expected to be effective on-site in the foreseeable future and contaminants will continue to migrate to the Hudson River.

Alternative G2 will be effective in reducing the toxicity, mobility and volume of VOCs, and possibly SVOCs in groundwater at the site through treatment. The degree of effectiveness of AS/SVE will need to be determined by a pilot test.

Alternative G3 will be effective at reducing the toxicity, mobility and volume of all contaminants in groundwater at the site. The use of a hydraulic barrier and extraction wells will mitigate migration of contaminated groundwater to the Hudson River. Removal and destruction of all the contaminants in groundwater allows this alternative to be considered irreversible.

Alternative G4 will likely be effective at reducing the levels of VOCs in groundwater, thereby reducing the toxicity of the groundwater and the volume of contaminants in groundwater. As stated previously, this alternative will not be effective at reducing metals and will likely not be effective in significantly reducing SVOCs in groundwater at the site. The effectiveness of this alternative will need to be determined by a pilot test.

Based on this comparative analysis, Alternative G3 will be the most effective followed by Alternatives G2 and G4, respectively. Alternative G1 will not be effective.

5.2.6 Implementability

Alternative G1 can be easily implemented. It is anticipated that existing groundwater monitoring wells can be utilized for continued monitoring, and therefore, new wells do not need to be installed.

Implementation of Alternative G2 will not be difficult since all of the necessary labor, equipment, materials and supplies are readily available. Potential problems may occur if subsurface obstructions, such as buried bulkheads and debris, are encountered. However, due to the shallow depth of the wells, these subsurface obstructions should not inhibit implementation of this alternative. Coordination with the appropriate regulatory agencies, such as the Westchester County Department of Environmental Facilities, would be required for discharge of the extracted water vapor/condensate to the POTW. However, no impediments to implementation are expected.

Completion of Alternative G2 will likely require 5 years. During this time, the portion of the site being utilized by the AS/SVE system may not be usable due to the need to install a surface/near surface liner to prevent short circuiting of the system. If immediate site usage is a priority, the AS/SVE system could be designed to remediate the groundwater contamination within a shorter period of time (i.e. approximately 2 to 3 years) through the addition of additional remediation zones. Decreasing the remediation time would increase the cost of this alternative, but would allow for a reduced time frame in which the site could be available for development.

Subsurface obstructions may also cause difficulties during implementation of Alternative G3, in particular, installation of the hydraulic barrier. However, the obstructions should not prevent installation of this system. Alternative G3 will also require approval of regulatory agencies for the discharge of treated groundwater to the Hudson River. Since the water will be treated to meet surface water quality standards it is not expected that difficulties will occur with regard to approved for discharge of the treated groundwater to the river.

Completion of Alternative G3 would likely require 15 years. If the alternative is not combined with a soil alternative that remediates or contains the source area, the extraction and treatment system will need to operate for a longer period of time. Similar to the discussion above for the AS/SVE system, if Alternative G3 is combined with a soil alternative that addresses source removal or containment (i.e. Alternative S3, S5 or S6) in the vadose zone, the duration of remediation can be reduced to perhaps 5 years. However, unlike AS/SVE, the majority of the site can be usable once the system has been installed and is operating since a surface/near surface liner is not required and piping will be below ground surface. Only a small portion of the site will need to be utilized to house the treatment system throughout the period of remediation.

Based on conversations with vendors, it appears that although Alternative G4 (chemical oxidation) is a developing technology, all the necessary labor, equipment, materials and supplies for installation of this system are available and will not cause delays in implementation. According to the information provided by vendors, remediation of the groundwater using chemical oxidation can be completed within a year. The actual injection program, once all of the injection points are installed, will take less than one month and reduction in the chlorobenzene levels is expected to occur immediately. Additional time would be incurred due to supplemental oxidant injection to address residual contamination. Therefore, this alternative would provide site development opportunities, in a shorter period of time compared to Alternatives G2 and G3.

All of the alternatives will be readily implementable with the simplest to implement being Alternative G1. Due to the relative complexity of the remediation systems required for

Alternatives G2 and G3, and the time required to complete groundwater remediation utilizing these alternatives, it is expected that Alternative G4 will be easier to implement and can provide for site development in a shorter period of time, as compared to Alternatives G2 and G3, respectively.

5.2.7 Cost

The estimated capital costs, and long-term (30-year) operation and maintenance (O&M), and monitoring present worth costs associated with the alternatives are presented in Table 5-3. A detailed breakdown of each estimate is provided in Appendix B.

The following assumptions were utilized in the preparation of the cost estimates:

- Costs are rounded to the nearest thousand dollars.
- All site work costs (e.g., well installation, etc.) were estimated using Means Site Work Cost Data for 1999, experience in construction and adjusted for hazardous site remediation, and discussion with remedial contractors and disposal facilities.

As shown in Table 5-3, Alternative G1 is the least costly, followed by Alternatives G4, G2 and G3.

As discussed in the implementation comparison, remediation of the groundwater utilizing AS/SVE (Alternative G2) could be accomplished in a shorter period of time if additional AS/SVE zones were installed. A shorter remediation time would allow for earlier site development. An additional $750,000 would be required to reduce of the treatment time to 2 to 3 years instead of 5 years. Since future site use and the time frame for development is undecided at the present time, the cost for Alternative G2 will remain at $2,183,000 for comparative purposes.

Table 5-3

GROUNDWATER ALTERNATIVES COST SUMMARY

Alternative	Estimated Capital Cost	Estimated Contingency and Engineering Fees	Present Worth of Annual Operating Maintenance and Monitoring Costs (30 years)	Total Estimated Costs Based on Present Worth
G1	$0	$0	$330,000	$330,000
G2	$798,000	$240,000	$1,145,000	$2,183,000
G3	$1,362,000	$476,000	$1,831,000	$3,669,000
G4	$1,300,000	$390,000	$171,000	$1,861,000

5.2.8 Community Acceptance

Due to the continued migration of contaminated groundwater to the Hudson River and potential contact with contaminated groundwater, it is not expected that Alternative G1 will be acceptable to the community.

Since Alternatives G2 and G3 are proven, commercially available remedial measures for the treatment of groundwater, it is likely that both of these alternatives will be acceptable to the community.

Since Alternative G4 is a developing technology it may not be as acceptable as Alternatives G2 and G3 to the community. However, if a pilot scale study can demonstrate the effectiveness of chemical oxidation at the site, it will likely be acceptable to the community.

Therefore, Alternative G2 would be the most acceptable followed by Alternatives G3, G4 and finally G1.

A summary of the comparison of alternatives is provided in Table 5-4.

Table 5-4

SUMMARY OF GROUNDWATER REMEDIAL ALTERNATIVE COMPARATIVE ANALYSIS TAPPAN TERMINAL SITE

Evaluation Criteria	Alternative G1 – No Action with Long-term Groundwater Monitoring	Alternative G2 – Air Sparging with Soil Vapor Extraction with Long-term Groundwater Monitoring	Alternative G3 – Hydraulic Barrier, Extraction and Treatment and Discharge to the Hudson River with Long-term Groundwater Monitoring	Alternative G4 - In situ Chemical Oxidation with Long-term Groundwater Monitoring
Protection of Human Health and the Environment	4	2	1	3
Compliance with SCGs	4	2	1	3
Short-term Impacts and Effectiveness	1	3	4	2
Long-term Effectiveness and Permanence	4	2	1	3
Reduction of Toxicity, Mobility or Volume through Treatment	4	2	1	3
Implementability	1	3	4	2
Cost	1 ($330,000)	3 ($2,183,000)	4 ($3,669,000)	2 ($1,861,000)
Community Acceptance	4	1	2	3
Total	23	18	18	21

Note: Lowest numerical score is highest ranking

Section 6

6.0 RECOMMENDED ALTERNATIVE

Based on the preliminary evaluation of the soil and groundwater remedial alternatives described in Section 4.0, and the detailed evaluation of alternatives in Section 5.0, *Alternative S5 – Hot Spot Excavation and Off-site Disposal (Mobil and Uhlich properties), Soil Cover (Mobil Property) and Pavement Cap (Uhlich property)* – is the recommended alternative for remediation of contaminated soil, and *Alternative G2 – Air Sparging with Soil Vapor Extraction and Long-Term Groundwater Monitoring* – is the recommended alternative for remediation of contaminated groundwater at the Tappen Terminal Site. These alternatives meet all of the remedial action objectives identified for the site and all of the feasibility study evaluation criteria, in particular, protection of human health and the environment, and attainment of the standards, criteria and guidelines established for the site.

For the soil alternatives, although Alternative S5 ranked slightly lower than Alternative S6 – Partial Excavation and Off-site Disposal (Mobil property), Hot Spot Excavation and Off-site Disposal (Uhlich property) and Pavement Cap (Uhlich property) – Alternative S6 is over $5 million dollars more costly than Alternative S5 with limited added benefit and potential creation of adverse impacts. As a result, Alternative S5 is the preferred alternative for remediation of soil at the site. Similarly for the groundwater alternatives, although Alternative G2 ranks equally with Alternative G3 – Hydraulic Barrier, Extraction and Treatment and Discharge to the Hudson River with Long-Term Groundwater Monitoring – Alternative G3 is approximately $1.5 million dollars more costly than Alternative G2 and would be more difficult to implement than Alternative G2. Therefore, Alternative G2 is the preferred alternative for remediation of the groundwater at the site.

Although the soil and groundwater alternatives have been evaluated separately throughout this feasibility study, these alternatives can be combined without any reduction in effectiveness or creation of impediments to implementability.

The remedial technologies that comprise Alternatives S5 and G2 are proven, effective and commercially available, and can be implemented almost immediately without adverse impacts. However, as stated previously, although air sparging with soil vapor extraction is an appropriate technology for the site, a pilot test to evaluate the site-specific effectiveness of the system and define the actual radius of influence of both the air sparging and soil vapor extraction wells is recommended to establish design parameters. A pilot test can be performed as a pre-design study, the results of which would be incorporated into the design of the recommended alternative.

Appendix A

APPENDIX A

SUPPLEMENTAL INVESTIGATION RESULTS

Table 1
Tappan Terminal RI/FS
Supplemental Soil Investigation - November 1999
Mobile Laboratory Gas Chromatograph Results

Line SR1

Instrument	GC*	GC	GC	GC	GC	GC*
Sample ID	SR1-W50	SR1-W50	SR1-W25	SR1-W5	SR1-E77	SR1-E77
Interval	(0-2)	(2-5)	(2-5)	(2-5)	(0-2)	(2-5)
Matrix	Soil	Soil	Soil	Soil	Soil	Soil
Date Collected	11/10/99	11/10/99	11/10/99	11/10/99	11/11/99	11/11/99
Target Compounds	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
1,1- DCE	25 U	25 U	25 U	25 U	25 U	25 U
Benzene	25 U	25 U	25 U	25 U	25 U	25 U
Trichloroethene	25 U	25 U	25 U	25 U	25 U	25 U
Toluene	25 U	25 U	25 U	25 U	25 U	25 U
Chlorobenzene	197	25 U	25 U	25 U	25 U	25 U
Comments	--	--	--	--	--	--

Line SR2

Instrument	GC	GC	GC	GC*	GC	GC	GC*	GC*	GC*
Sample ID	SR2-W50	SR2-W50	SR2-W25	SR2-W25	SR2-E5	SR2-E43	SR2-E43	SR2-E130	SR2-E130
Interval	(0-2)	(2-5)	(0-2)	(2-5)	(2-5)	(0-2)	(2-4)	(0-2)	(2-5)
Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Date Collected	11/11/99	11/11/99	11/11/99	11/11/99	11/11/99	11/11/99	11/11/99	11/12/99	11/12/99
Target Compounds	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
1,1- DCE	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Benzene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Trichloroethene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Toluene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Chlorobenzene	25 U	25 U	250	>20 PPM	25 U	25 U	25 U	25 U	25 U
Comments	--	--	--	visual oil	--	--	--	--	--

Line SR3

Instrument	GC	GC	GC	GC	GC*	GC	GC	GC	GC
Sample ID	SR3-W140	SR3-W60	SR3-W60	SR3-E14	SR3-E14	SR3-E41	SR3-E41	SR3-E90	SR3-E90
Interval	(2-4)	(0-2)	(2-5)	(0-2)	(2-5)	(0-2)	(2-5)	(0-2)	(2-5)
Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Date Collected	11/12/99	11/11/99	11/11/99	11/10/99	11/10/99	11/10/99	11/10/99	11/12/99	11/12/99
Target Compounds	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
1,1- DCE	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Benzene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Trichloroethene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Toluene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Chlorobenzene	25 U	250	350	25 U	27500	25 U	25 U	25 U	25 U
Comments	--	--	--	--	--	--	--	--	--

Line SR4

Instrument	GC	GC	GC	GC	GC*	GC
Sample ID	SR4-W40	SR4-W40	SR4-E20	SR4-E20	SR4-E40	SR4-E40
Interval	(0-2)	(2-4)	(0-2)	(2-5)	(0-2)	(2-5)
Matrix	Soil	Soil	Soil	Soil	Soil	Soil
Date Collected	11/11/99	11/11/99	11/09/99	11/09/99	11/09/99	11/09/99
Target Compounds	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
1,1- DCE	25 U	25 U	25 U	25 U	25 U	25 U
Benzene	25 U	25 U	25 U	25 U	25 U	25 U
Trichloroethene	25 U	25 U	25 U	25 U	25 U	25 U
Toluene	25 U	25 U	25 U	25 U	25 U	25 U
Chlorobenzene	25 U	25 U	25 U	25 U	25 U	25 U
Comments	--	visual oil	--	--	--	--

Table 1 (continued)
Tappan Terminal RI/FS
Supplemental Soil Investigation - November 1999
Mobile Laboratory Gas Chromatograph Results

Line SR5

Instrument	GC*	GC*	GC*	GC	GC
Sample ID	SR5-W50	SR5-E12	SR5-E12	SR5-E30	SR5-E30
Interval	(2-5)	(0-2)	(3-4.5)	(0-2)	(2-5)
Matrix	Soil	Soil	Soil	Soil	Soil
Date Collected	11/11/99	11/10/99	11/10/99	11/11/99	11/11/99
Target Compounds	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
1,1- DCE	25 U	25 U	25 U	25 U	25 U
Benzene	36	25 U	25 U	25 U	25 U
Trichloroethene	25 U	25 U	25 U	25 U	25 U
Toluene	25 U	25 U	25 U	25 U	25 U
Chlorobenzene	716	25 U	25 U	25 U	25 U
Comments	TPH, v. oil	--	visual oil	--	TPH, v. oil

Line SR6

Instrument	GC	GC	GC
Sample ID	SR6-W5	SR6-E50	SR6-E50
Interval	(3-5)	(0-2)	(2-5)
Matrix	Soil	Soil	Soil
Date Collected	11/11/99	11/11/99	11/11/99
Target Compounds	(ug/kg)	(ug/kg)	(ug/kg)
1,1- DCE	25 U	25 U	25 U
Benzene	25 U	25 U	25 U
Trichloroethene	25 U	25 U	25 U
Toluene	25 U	25 U	25 U
Chlorobenzene	25 U	25 U	479
Comments	TPH, v. oil	--	--

Location SB-3

Instrument	GC	GC*	GC*	GC	GC*	GC
Sample ID	SB3	SB3	SB3-N25	SB3-N25	SB3-E25'	SB3-E25'
Interval	(0-2)	(2-4)	(0-2)	(2-4)	(0-2)	(2-4)
Matrix	Soil	Soil	Soil	Soil	Soil	Soil
Date Collected	11/08/99	11/08/99	11/09/99	11/09/99	11/08/99	11/08/99
Target Compounds	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
1,1- DCE	25 U	25 U	25 U	25 U	25 U	25 U
Benzene	25 U	25 U	103	25 U	25 U	25 U
Trichloroethene	25 U	25 U	25 U	25 U	25 U	25 U
Toluene	25 U	25 U	25 U	25 U	25 U	25 U
Chlorobenzene	25 U	25 U	25 U	25 U	>500	25 U
Comments	visual oil	--	--	visual oil	--	visual oil

Location SB-3 (continued)

Instrument	GC	GC	GC	GC
Sample ID	SB3-S25'	SB3-S25'	SB3-W25'	SB3-W25'
Interval	(0-2)	(2-4)	(0-2)	(2-4)
Matrix	Soil	Soil	Soil	Soil
Date Collected	11/08/99	11/08/99	11/08/99	11/08/99
Target Compounds	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
1,1- DCE	25 U	25 U	25 U	25 U
Benzene	25 U	25 U	25 U	25 U
Trichloroethene	25 U	25 U	25 U	25 U
Toluene	25 U	25 U	25 U	25 U
Chlorobenzene	25 U	25 U	25 U	0.1PPM
Comments	--	visual oil	visual oil	visual oil

Table 1 (continued)
Tappan Terminal RI/FS
Supplemental Soil Investigation - November 1999
Mobile Laboratory Gas Chromatograph Results (continued)

Location SB-8

Instrument	GC*	GC	GC*	GC	GC	GC*	GC	GC*
Sample ID	SB8-N25	SB8-N12	SB8-N12	SB8-E25	SB8-E25	SB8-E12	SB8-S25	SB8-S25
Interval	(2-5)	(0-2)	(2-4)	(0-2)	(2-4)	(2-4)	(0-2)	(2-5)
Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Date Collected	11/09/99	11/10/99	11/10/99	11/09/99	11/09/99	11/10/99	11/09/99	11/09/99
Target Compounds	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
1,1- DCE	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Benzene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Trichloroethene	29	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Toluene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Chlorobenzene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Comments	--	--	--	--	--	--	--	--

Location SB-8 (continued)

Instrument	GC	GC	GC*	GC	GC	GC
Sample ID	SB8-S12	SB8-W25	SB8-W25	SB8-N25	SB8-W12	SB8-W12
Interval	(0-2)	(0-2)	(2-5)	(0-2)	(0-2)	(2-4)
Matrix	Soil	Soil	Soil	Soil	Soil	Soil
Date Collected	11/10/99	11/09/99	11/09/99	11/09/99	11/10/99	11/10/99
Target Compounds	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
1,1- DCE	25 U	25 U	25 U	12 J	25 U	25 U
Benzene	25 U	25 U	25 U	25 U	25 U	25 U
Trichloroethene	25 U	14 J	35	35	25 U	25 U
Toluene	25 U	25 U	25 U	25 U	25 U	25 U
Chlorobenzene	25 U	25 U	25 U	25 U	25 U	25 U
Comments	--	--	--	--	--	--

Notes:

U - non detect

NA- not analyzed by mobile lab gas chromatograph

J- estimated value

* Confirmatory GC/MS analysis performed on this sample

-- no comments

TPH- GC curve suggests TPH compounds are present

visual oil - petroleum-like characteristics observed in split spoon sample including odor, sheen, elevated PID measurements

[ ] - value exceeds soil cleanup objective of 1,700 ug/kg

Table 2
Tappan Terminal RI/FS
Supplemental Groundwater Investigation - November 1999
Mobile Laboratory Gas Chromatograph Results

Line SR1

Instrument	GC	GC	GC	GC*
Sample ID	SR1-W50	SR1-W25	SR1-W5	SR1-E77
Matrix	Water	Water	Water	Water
Date Collected	11/10/99	11/10/99	11/10/99	11/11/99
Target Compounds	(ug/l)	(ug/l)	(ug/l)	(ug/l)
1,1- DCE	25 U	25 U	25 U	25 U
Benzene	25 U	25 U	25 U	25 U
Trichloroethene	25 U	25 U	25 U	25 U
Toluene	25 U	25 U	25 U	25 U
Chlorobenzene	25 U	>1PPM	1067	25 U
Comments	--	--	--	--

Line SR2

Instrument	GC*	GC*	GC*	GC*
Sample ID	SR2-E43	SR2-E5	SR2-W50	SR2-W25
Matrix	Water	Water	Water	Water
Date Collected	11/10/99	11/11/99	11/11/99	11/11/99
Target Compounds	(ug/l)	(ug/l)	(ug/l)	(ug/l)
1,1- DCE	25 U	25 U	25 U	25 U
Benzene	25 U	25 U	25 U	25 U
Trichloroethene	25 U	25 U	25 U	25 U
Toluene	25 U	25 U	25 U	25 U
Chlorobenzene	464	>1PPM	50	>5 PPM
Comments	--	--	--	--

Line SR3

Instrument	GC*	GC*	GC*	GC*	GC*	GC*
Sample ID	SR3-W180	SR3-W140	SR3-W60	SR3-E14	SR3-E41	SR3-E90
Matrix	Water	Water	Water	Water	Water	Water
Date Collected	11/12/99	11/12/99	11/11/99	11/10/99	11/10/99	11/12/99
Target Compounds	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
1,1- DCE	25 U	25 U	25 U	25 U	25 U	25 U
Benzene	25 U	25 U	25 U	25 U	25 U	25 U
Trichloroethene	25 U	25 U	25 U	89	25 U	25 U
Toluene	25 U	25 U	25 U	25 U	25 U	25 U
Chlorobenzene	29	1127	3100	500	25 U	25 U
Comments	--	--	--	--	--	--

Line SR4

Instrument	GC*	GC*	GC*	GC*
Sample ID	SR4-W170	SR4-W40	SR4-E20	SR4-E40
Matrix	Water	Water	Water	Water
Date Collected	11/12/99	11/11/99	11/09/99	11/09/99
Target Compounds	(ug/l)	(ug/l)	(ug/l)	(ug/l)
1,1- DCE	25 U	25 U	25 U	25 U
Benzene	25 U	25 U	25 U	25 U
Trichloroethene	25 U	25 U	25 U	25 U
Toluene	25 U	27	25 U	25 U
Chlorobenzene	43	78	25 U	25 U
Comments	--	TPH	--	--

Table 2 (continued)
Tappan Terminal RI/FS
Supplemental Groundwater Investigation - November 1999
Mobile Laboratory Gas Chromatograph Results

Line SR5

Instrument	GC*	GC*	GC*	GC*
Sample ID	SR5-W115	SR5-W50	SR5-E12	SR5-E30
Matrix	Water	Water	Water	Water
Date Collected	11/12/99	11/11/99	11/10/99	11/11/99
Target Compounds	(ug/l)	(ug/l)	(ug/l)	(ug/l)
1,1- DCE	25 U	25 U	25 U	25 U
Benzene	25 U	232	25 U	25 U
Trichloroethene	25 U	25 U	25 U	25 U
Toluene	25 U	25 U	25 U	25 U
Chlorobenzene	198	3600	25 U	33
Comments	--	--	--	TPH

Line SR6

Instrument	GC*
Sample ID	SR6-W5
Matrix	Water
Date Collected	11/11/99
Target Compounds	(ug/l)
1,1- DCE	25 U
Benzene	25 U
Trichloroethene	25 U
Toluene	25 U
Chlorobenzene	32
Comments	TPH

Location SB-3

Instrument	GC*	GC*	GC*	GC*	GC*	GC*
Sample ID	SB3	SB3-N25	SB3-E25'	SB3-S25'	SB3-S50	SB3-W25'
Matrix	water	water	water	water	Water	water
Date Collected	11/08/99	11/09/99	11/08/99	11/08/99	11/11/99	11/08/99
Target Compounds	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
1,1- DCE	25 U	25 U	NA	25 U	25 U	25 U
Benzene	25 U	25 U	NA	25 U	25 U	25 U
Trichloroethene	25 U	25 U	NA	25 U	25 U	25 U
Toluene	25 U	25 U	NA	25 U	25 U	25 U
Chlorobenzene	25 U	25 U	NA	> 1PPM	1140	25 U
Comments	--	--	--	--	--	--

Location SB-8

Instrument	GC	GC	GC	GC	GC	GC	GC	GC
Sample ID	SB8-W25	SB8-W12	SB8-E12	SB8-E25	SB8-N25	SB8-N12	SB8-S12	SB8-S25
Matrix	Water	Water	Water	Water	Water	Water	Water	Water
Date Collected	11/09/99	11/10/99	11/10/99	11/09/99	11/09/99	11/10/99	11/10/99	11/09/99
Target Compounds	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
1,1- DCE	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Benzene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Trichloroethene	25 U	25 U	25 U	28	12 J	25 U	25 U	13 J
Toluene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Chlorobenzene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Comments	--	--	--	--	--	--	--	--

* Confirmatory GC/MS analyses performed on this sample

NA - not analyzed by portable lab gas chromatograph (GC)

TPH- GC curve suggests TPH compounds are present

[boxed] - value exceeds groundwater standard of 5 ug/l for chlorobenzene, trichloroethene and toluene and 1 ug/l for benzene.

TABLE 3
TAPPAN TERMINAL SITE
SUPPLEMENTAL REMEDIAL INVESTIGATION
DIRECT PUSH SUBSURFACE SOIL SAMPLE RESULTS - NOVEMBER 1999
VOLATILE ORGANIC COMPOUNDS BY MOBILE LAB GC/MS

Sample Identification	SB3	SB3-N25	SB3-S50	SB3-W25	SB8-W25	SB8	SB8-E12	SB8-E25	
Sample Depth	2-4'	0-2'	2-4'	2-4'	2-5'	2-5'	2-4'	0-2'	NYSDEC
Date of Collection	11/08/99	11/09/99	11/11/99	11/08/99	11/09/99	11/12/99	11/10/99	11/09/99	Recommended
Dilution Factor	1.0	1.0	125.0	460.0	1.0	1.0	1.0	1.0	Soil Clean-Up
Percent Moisture	0	21.2	10.1	0	22.4	13.8	18.4	13.8	Objective
Units	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Dichlorodifluoromethane	U	U	U	U	U	U	U	U	----
Chloromethane	U	U	U	U	U	U	U	U	----
Vinyl Chloride	U	U	U	U	U	U	U	U	200
Bromomethane	U	U	U	U	U	U	U	U	----
Chloroethane	U	U	U	U	U	U	U	U	1,900
Ethyl Ether	U	U	1100	U	U	U	U	U	----
tert-Butyl-Methyl-Ether	U	U	U	U	U	U	U	U	----
Trichlorofluoromethane	U	U	U	U	U	U	U	U	----
Acrolein	U	U	U	U	U	U	U	U	----
Acrylonitrile	U	U	U	U	U	U	U	U	----
1,1-Dichloroethene	U	U	U	U	U	U	U	U	400
Carbon Disulfide	U	U	U	U	U	U	U	U	2,700
Acetone	U	U	U	U	U	U	140	U	200
Methylene Chloride	7200 B	U	260 JB	3400 JB	U	18 JB	5.1 JB	U	100
trans 1,2-Dichloroethene	U	U	U	U	U	U	7.7	3.8 J	300*
cis 1,2-Dichloroethene	U	U	U	U	U	130	100	17	300*
1,1-Dichloroethane	U	U	U	U	U	U	U	U	200
Chloroform	U	U	U	U	U	U	U	U	300
1,2-Dichloroethane	U	U	U	U	U	U	U	U	100
2-Butanone	U	U	U	U	U	21 J	U	U	300
1,1,1-Trichloroethane	U	U	U	U	U	U	U	U	800
Carbon Tetrachloride	U	U	U	U	U	U	U	U	600
Benzene	U	20	U	U	U	U	U	U	60
Trichloroethene	U	9.6 J	U	U	U	37	19	4.5 J	700
1,2-Dichloropropane	U	U	U	U	U	U	U	U	----
Bromodichloromethane	U	U	U	U	U	U	U	U	----
cis-1,3-Dichloropropene	U	U	U	U	U	U	U	U	----
trans 1,3-Dichloropropene	U	U	U	U	U	U	U	U	----
1,1,2-Trichloroethane	U	U	U	U	U	U	U	U	----
Dibromochloromethane	U	U	U	U	U	U	U	U	----
Bromoform	U	U	U	U	U	U	U	U	----
4-Methyl-2-Pentanone	U	U	U	U	U	U	U	U	1,000
Toluene	U	13	150 J	U	U	U	U	4.3 J	1,500
Tetrachloroethene	U	6.4 J	U	U	U	30	34	5.5 J	1,400
2-Hexanone	U	U	U	U	U	U	U	U	----
Chlorobenzene	U	U	1200	2200 J	U	10 J	U	2.6 J	1,700
Ethylbenzene	U	U	U	U	U	U	U	4.5 J	5,500
M&P Xylene	U	U	U	U	U	U	U	U	1,200**
O Xylene	U	3.2 J	U	U	U	U	U	U	1,200**
Styrene	U	U	U	U	U	U	U	U	----
1,1,2,2-Tetrachloroethane	U	U	U	U	U	U	U	U	600
1,3-Dichlorobenzene	U	U	U	U	U	U	U	U	----
1,4-Dichlorobenzene	U	U	U	U	U	U	U	U	----
1,2-Dichlorobenzene	U	U	U	U	U	U	U	U	----
Naphthalene	U	U	U	U	U	U	U	U	----
Total VOCs	7200	52.2	2710	5600	0	246	305.8	42.2	10,000
Total VOC TICs	---	0	0	0	0	958	0	0	

QUALIFIERS:

U: Compound analyzed for but not detected

J: Compound found at a concentration below the CRDL, value estimated

D: Result taken from reanalysis at a 1:250 dilution

U*: Result qualified as non-detect based on validation criteria

B: Compound found in the blank as well as the sample

---: Not established

[boxed cell] Indicates value exceeds the NYSDEC recommended soil clean up objective.

NOTES:

To determine the detection limit for each sample, use the following equation: (CRDL)*(DF) where CRDL = contract required detection limit, DF = dilution factor and %S = percent solids..

TABLE 3 (continued)
TAPPAN TERMINAL SITE
SUPPLEMENTAL REMEDIAL INVESTIGATION
DIRECT PUSH SUBSURFACE SOIL SAMPLE RESULTS - NOVEMBER 1999
VOLATILE ORGANIC COMPOUNDS BY MOBILE LAB GC/MS

Sample Identification	SB8-N25	SB8-N25	SB8-N12	SB8-S25	SR1-W50	SR1-E77	SR2-W25	SR2-E43	
Sample Depth	0-2'	2-5'	2-4'	2-5'	0-2'	2-5'	2-5'	2-4'	NYSDEC
Date of Collection	11/09/99	11/09/99	11/10/99	11/09/99	11/10/99	11/11/99	11/11/99	11/10/99	Recommended
Dilution Factor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	Soil Clean-Up
Percent Moisture	12.5	13	21.3	16.7	17.7	15.2	23.8	16.2	Objective
Units	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Dichlorodifluoromethane	U	U	U	U	U	U	U	U	----
Chloromethane	U	U	U	U	U	U	U	U	----
Vinyl Chloride	U	U	U	U	U	U	U	U	200
Bromomethane	U	U	U	U	U	U	U	U	----
Chloroethane	U	U	U	U	U	U	U	U	1,900
Ethyl Ether	U	U	U	U	U	U	U	U	----
tert-Butyl-Methyl-Ether	U	U	U	U	U	U	U	U	----
Trichlorofluoromethane	U	U	U	U	U	U	U	U	----
Acrolein	U	U	U	U	U	U	U	U	----
Acrylonitrile	U	U	U	U	U	U	U	U	----
1,1-Dichloroethene	37	U	U	U	U	U	U	U	400
Carbon Disulfide	U	U	U	U	U	U	U	U	2,700
Acetone	U	U	200 E	U	U	150	U	U	200
Methylene Chloride	U	U	5.5 JB	U	30 JB	28 JB	1000 JB	20 JB	100
trans 1,2-Dichloroethene	U	U	U	U	U	U	U	U	300*
cis 1,2-Dichloroethene	54	U	4 J	U	U	U	U	U	300*
1,1-Dichloroethane	U	U	U	U	U	U	U	U	200
Chloroform	U	U	U	U	U	U	U	U	300
1,2-Dichloroethane	U	U	U	U	U	U	U	U	100
2-Butanone	U	U	U	U	U	U	U	U	300
1,1,1-Trichloroethane	U	U	U	U	U	U	U	U	800
Carbon Tetrachloride	U	U	U	U	U	U	U	U	600
Benzene	5.6 J	U	U	U	U	U	U	U	60
Trichloroethene	23	U	U	U	U	U	U	U	700
1,2-Dichloropropane	U	U	U	U	U	U	U	U	----
Bromodichloromethane	U	U	U	U	U	U	U	U	----
cis-1,3-Dichloropropene	U	U	U	U	U	U	U	U	----
trans 1,3-Dichloropropene	U	U	U	U	U	U	U	U	----
1,1,2-Trichloroethane	U	U	U	U	U	U	U	U	----
Dibromochloromethane	U	U	U	U	U	U	U	U	----
Bromoform	U	U	U	U	U	U	U	U	----
4-Methyl-2-Pentanone	U	U	U	U	U	U	U	U	1,000
Toluene	8.4 J	U	U	U	U	U	U	U	1,500
Tetrachloroethene	50	U	U	U	U	U	U	18 J	1,400
2-Hexanone	U	U	U	U	U	U	U	U	----
Chlorobenzene	U	U	U	U	260	39	26000	190	1,700
Ethylbenzene	6.1 J	U	U	U	U	U	U	U	5,500
M&P Xylene	U	U	U	U	U	U	U	U	1,200**
O Xylene	U	U	U	U	U	U	U	U	1,200**
Styrene	U	U	U	U	U	U	U	U	----
1,1,2,2-Tetrachloroethane	U	U	U	U	U	U	U	U	600
1,3-Dichlorobenzene	U	U	U	U	U	U	U	U	----
1,4-Dichlorobenzene	U	U	U	U	U	U	U	U	----
1,2-Dichlorobenzene	U	U	U	U	U	U	U	U	----
Naphthalene	U	U	U	U	U	82	U	U	----
Total VOCs	184.1	0	209.5	0	290	299	27000	228	10,000
Total VOC TICs	0	0	0	0	0	927	6600	200	

QUALIFIERS:

U: Compound analyzed for but not detected

J: Compound found at a concentration below the CRDL, value estimated

D: Result taken from reanalysis at a 1:250 dilution

U*: Result qualified as non-detect based on validation criteria

E: Result exceeds calibaration limits, no dilution run because analyte is not a target for this investigation

B: Compound found in the blank as well as the sample

---: Not established

[Boxed value] Indicates value exceeds the NYSDEC recommended soil clean up objective.

NOTES:

To determine the detection limit for each sample, use the following equation: (CRDL)*(DF) where CRDL = contract required detection limit, DF = dilution factor and %S = percent solids..

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TABLE 3 (continued)
TAPPAN TERMINAL SITE
SUPPLEMENTAL REMEDIAL INVESTIGATION
DIRECT PUSH SUBSURFACE SOIL SAMPLE RESULTS - NOVEMBER 1999
VOLATILE ORGANIC COMPOUNDS BY MOBILE LAB GC/MS

Sample Identification	SR2-E130	SR2-E130	SR3-E14	SR4-E40	SR5-W50	SR5-E12	SR5-E12	
Sample Depth	0-2'	2-5'	2-5'	0-2'	2-5'	0-2'	3-4.5'	NYSDEC
Date of Collection	11/12/99	11/12/99	11/10/99	11/09/99	11/12/99	11/11/99	11/10/99	Recommended
Dilution Factor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	Soil Clean-Up
Percent Moisture	20.2	16	18.8	17.2	14.2	12.5	19.3	Objective
Units	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Dichlorodifluoromethane	U	U	U	U	U	U	U	----
Chloromethane	U	U	U	U	U	U	U	----
Vinyl Chloride	U	U	U	U	U	U	U	200
Bromomethane	U	U	U	U	U	U	U	----
Chloroethane	U	U	U	U	U	U	U	1,900
Ethyl Ether	U	U	U	U	U	U	U	----
tert-Butyl-Methyl-Ether	U	U	U	U	U	U	U	----
Trichlorofluoromethane	U	U	U	U	U	U	U	----
Acrolein	U	U	U	U	U	U	U	----
Acrylonitrile	U	U	U	U	U	U	U	----
1,1-Dichloroethene	U	U	U	U	U	U	U	400
Carbon Disulfide	U	U	U	U	U	U	U	2,700
Acetone	U	U	U	U	U	270	350	200
Methylene Chloride	13 JB	13 JB	380 JB	U	47 JB	26 JB	29 JB	100
trans 1,2-Dichloroethene	U	U	U	U	U	U	U	300*
cis 1,2-Dichloroethene	U	U	U	U	U	U	U	300*
1,1-Dichloroethane	U	U	U	U	U	U	U	200
Chloroform	11 J	U	U	U	U	U	U	300
1,2-Dichloroethane	U	U	U	U	U	U	U	100
2-Butanone	U	U	U	U	U	U	U	300
1,1,1-Trichloroethane	U	U	U	U	U	U	U	800
Carbon Tetrachloride	U	U	U	U	U	U	U	600
Benzene	U	U	U	U	58 J	U	U	60
Trichloroethene	U	U	U	4.4 J	U	U	U	700
1,2-Dichloropropane	U	U	U	U	U	U	U	----
Bromodichloromethane	U	U	U	U	U	U	U	----
cis-1,3-Dichloropropene	U	U	U	U	U	U	U	----
trans 1,3-Dichloropropene	U	U	U	U	U	U	U	----
1,1,2-Trichloroethane	U	U	U	U	U	U	U	----
Dibromochloromethane	U	U	U	U	U	U	U	----
Bromoform	U	U	U	U	U	U	U	----
4-Methyl-2-Pentanone	U	U	U	U	U	U	U	1,000
Toluene	U	U	150 J	U	16 J	U	U	1,500
Tetrachloroethene	340	230	U	24	U	U	U	1,400
2-Hexanone	U	U	U	U	U	U	U	----
Chlorobenzene	12 J	66	25000	36	9200 D	U	U	1,700
Ethylbenzene	U	U	U	U	140	U	U	5,500
M&P Xylene	U	U	U	U	64 J	U	U	1,200**
O Xylene	U	U	U	U	260	U	U	1,200**
Styrene	U	U	U	U	U	U	U	----
1,1,2,2-Tetrachloroethane	U	U	U	U	U	U	U	600
1,3-Dichlorobenzene	U	U	U	U	U	U	U	----
1,4-Dichlorobenzene	U	U	U	U	690	U	U	----
1,2-Dichlorobenzene	U	U	160 J	U	980	U	U	----
Naphthalene	U	U	U	U	U	U	U	----
Total VOCs	376	309	25690	64.4	11455	296	379	10,000
Total VOC TICs	0	0	0	0	6640	0	0	

QUALIFIERS:

U: Compound analyzed for but not detected

J: Compound found at aconcentration below the CRDL, value estimated

D: Result taken from reanalysis at a 1:250 dilution

U*: Result qualified as non-detect based on validation criteria

---: Not established

NOTES:

To determine the detection limit for each sample, use the following equation: (CRDL)*(DF) where CRDL = contract required detection limit, DF = dilution factor and %S = percent solids..

[box] Indicates value exceeds the NYSDEC recommended soil clean up objective.

TABLE 4
TAPPAN TERMINAL SITE
SUPPLEMENTAL REMEDIAL INVESTIGATION
DIRECT PUSH GROUNDWATER SAMPLE RESULTS - NOVEMBER 1999
VOLATILE ORGANIC COMPOUNDS BY MOBILE LAB GC/MS

Sample Identification	SB3	SB3-W25	SB3-E25	SB3-N25	SB3-S50	SB8-W25	SB8-W12	SB8-E12	SB8-E25	NYSDEC Class GA Groundwater Standards
Date of Collection	11/8/99	11/09/99	11/09/99	11/09/99	11/11/99	11/09/99	11/10/99	11/10/99	11/09/99	
Dilution Factor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Units	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
Dichlorodifluoromethane	U	U	U	U	U	U	U	U	U	----
Chloromethane	U	U	U	U	U	U	U	U	U	5 ST
Vinyl Chloride	U	U	U	U	U	U	U	U	U	2 ST
Bromomethane	U	U	U	U	U	U	U	U	U	5 ST
Chloroethane	U	U	U	U	U	U	U	U	U	5 ST
Ethyl Ether	U	U	U	82	9300	U	U	U	U	----
tert-Butyl-Methyl-Ether	U	U	U	U	U	U	U	U	U	----
Trichlorofluoromethane	U	U	U	U	U	U	U	U	U	----
Acrolein	U	U	U	U	U	U	U	U	U	----
Acrylonitrile	U	U	U	U	U	U	U	U	U	----
1,1-Dichloroethene	U	U	U	U	U	U	U	U	U	5 ST
Carbon Disulfide	U	U	U	U	U	U	U	U	U	----
Acetone	U	U	U	U	U	U	U	40	U	50GV
Methylene Chloride	U	U	U	U	**290 JB**	U	U	U	U	5 ST
trans 1,2-Dichloroethene	U	U	U	U	U	U	U	U	U	----
cis 1,2-Dichloroethene	U	U	U	U	U	U	U	2.1 J	U	----
1,1-Dichloroethane	U	U	U	U	U	U	U	U	U	5 ST
Chloroform	U	U	U	U	U	U	U	U	U	7 ST
1,2-Dichloroethane	U	U	U	U	U	U	U	U	U	0.6 ST
2-Butanone	U	U	U	U	U	U	U	U	U	50GV
1,1,1-Trichloroethane	U	U	U	U	U	U	U	U	U	5 ST
Carbon Tetrachloride	U	U	U	U	U	U	U	U	U	5 ST
Benzene	U	U	**32**	**2.8 J**	U	U	U	U	U	1 ST
Trichloroethene	U	U	U	U	U	U	U	U	U	5 ST
1,2-Dichloropropane	U	U	U	U	U	U	U	U	U	1 ST
Bromodichloromethane	U	U	U	U	U	U	U	U	U	50GV
cis-1,3-Dichloropropene	U	U	U	U	U	U	U	U	U	0.4 ST **
trans-1,3-Dichloropropene	U	U	U	U	U	U	U	U	U	0.4 ST **
1,1,2-Trichloroethane	U	U	U	U	U	U	U	U	U	1 ST
Dibromochloromethane	U	U	U	U	U	U	U	U	U	50GV
Bromoform	U	U	U	U	U	U	U	U	U	50GV
4-Methyl-2-Pentanone	U	U	U	U	U	U	U	U	U	----
Toluene	U	U	U	U	U	U	U	U	U	5 ST
Tetrachloroethene	U	U	U	U	U	U	U	1.3 J	U	5 ST
2-Hexanone	U	U	U	U	U	U	U	U	U	50GV
Chlorobenzene	U	U	**26**	**14**	**1600**	U	U	U	U	5 ST
Ethylbenzene	U	U	U	U	U	U	U	U	U	5 ST
M&P Xylene	U	U	U	U	U	U	U	U	U	----
O Xylene	U	U	U	U	U	U	U	U	U	----
Styrene	U	U	U	U	U	U	U	U	U	5 ST
1,1,2,2-Tetrachloroethane	U	U	U	U	U	U	U	U	U	5 ST
1,3-Dichlorobenzene	U	U	U	U	U	U	U	U	U	----
1,4-Dichlorobenzene	U	U	U	U	U	U	U	U	U	----
1,2-Dichlorobenzene	U	U	U	U	U	U	U	U	U	----
Naphthalene	U	U	U	U	U	U	U	U	U	5 ST
Total VOCs	0	0	58	99	11190	0	0	43	0	----
Total VOC TICs	0	0	9470	1599	700	0	0	0	0	----

QUALIFIERS:
U: Compound analyzed for but not detected
B: Compound found in the blank as well as the sample
J: Compound found at a concentration below the CRDL, value estimated
D: Value is a result of analysis with a dilution factor of 20.0
D*: Value is a result of analysis with a dilution factor of 10.0
D**: Value is a result of analysis with a dilution factor of 5.0
U*: Result qualified as non-detect based upon validation criteria

NOTES:
*: Value pertains to cis-1,2 Dichloroethene and trans-1,2 Dichloroethene individually
**: Value pertains to the sum of the isomers
GV: Guidance Value
ST: Standard
----: Not established
[box] Indicates value exceeds NYSDEC Class GA groundwater standard or guidance value.

TABLE 4 (continued)
TAPPAN TERMINAL SITE
SUPPLEMENTAL REMEDIAL INVESTIGATION
DIRECT PUSH GROUNDWATER SAMPLE RESULTS - NOVEMBER 1999
VOLATILE ORGANIC COMPOUNDS BY MOBILE LAB GC/MS

Sample Identification	SB8-N25	SB8-N12	SB8-S12	SB8-S25	SR1-E77	SR2-W50	SR2-W25	SR2-E5	SR2-E43	NYSDEC Class GA Groundwater Standards
Date of Collection	11/09/99	11/10/99	11/10/99	11/09/99	11/10/99	11/11/99	11/10/99	11/11/99	11/10/99	
Dilution Factor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5.0	1.0	
Units	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
Dichlorodifluoromethane	U	U	U	U	U	U	U	U	U	----
Chloromethane	U	U	U	U	U	U	U	U	U	5 ST
Vinyl Chloride	U	U	U	U	U	U	U	U	U	2 ST
Bromomethane	U	U	U	U	U	U	U	U	U	5 ST
Chloroethane	U	U	U	U	U	U	U	U	U	5 ST
Ethyl Ether	U	U	U	U	U	U	U	U	U	----
tert-Butyl-Methyl-Ether	U	U	U	U	U	U	U	U	U	----
Trichlorofluoromethane	U	U	U	U	U	U	U	U	U	----
Acrolein	U	U	U	U	U	U	U	U	U	----
Acrylonitrile	U	U	U	U	U	U	U	U	U	----
1,1-Dichloroethene	U	U	U	U	U	U	U	U	U	5 ST
Carbon Disulfide	U	U	U	U	U	U	U	U	U	----
Acetone	U	U	U	U	37	U	U	U	U	50GV
Methylene Chloride	U	U	U	U	U	U	190 JB	12 JB	U	5 ST
trans 1,2-Dichloroethene	U	U	U	U	U	U	U	U	U	----
cis 1,2-Dichloroethene	U	2.1 J	U	U	U	U	50 J	U	11	----
1,1-Dichloroethane	U	2.8 J	U	U	U	U	U	U	U	5 ST
Chloroform	U	U	1.9 J	U	U	U	U	U	U	7 ST
1,2-Dichloroethane	U	U	U	U	U	U	U	U	U	0.6 ST
2-Butanone	U	U	U	U	U	U	U	U	U	50GV
1,1,1-Trichloroethane	U	U	U	U	U	U	U	U	U	5 ST
Carbon Tetrachloride	U	U	U	U	U	U	U	U	U	5 ST
Benzene	U	U	U	U	U	U	U	6.3 J	U	1 ST
Trichloroethene	U	U	U	U	U	U	U	U	9.2	5 ST
1,2-Dichloropropane	U	U	U	U	U	U	U	U	U	1 ST
Bromodichloromethane	U	U	U	U	U	U	U	U	U	50GV
cis-1,3-Dichloropropene	U	U	U	U	U	U	U	U	U	0.4 ST **
trans-1,3-Dichloropropene	U	U	U	U	U	U	U	U	U	0.4 ST **
1,1,2-Trichloroethane	U	U	U	U	U	U	U	U	U	1 ST
Dibromochloromethane	U	U	U	U	U	U	U	U	U	50GV
Bromoform	U	U	U	U	U	U	U	U	U	50GV
4-Methyl-2-Pentanone	U	U	U	U	U	U	U	U	U	----
Toluene	U	U	U	U	U	U	U	U	1.1 J	5 ST
Tetrachloroethene	U	U	U	U	U	U	U	U	1.9 J	5 ST
2-Hexanone	U	U	U	U	U	U	U	U	U	50GV
Chlorobenzene	U	U	U	U	U	81	6800	940	1200 D	5 ST
Ethylbenzene	U	U	U	U	U	U	U	U	U	5 ST
M&P Xylene	U	U	U	U	U	U	U	U	U	----
O Xylene	U	U	U	U	U	U	U	U	U	----
Styrene	U	U	U	U	U	U	U	U	U	5 ST
1,1,2,2-Tetrachloroethane	U	U	U	U	U	U	U	U	U	5 ST
1,3-Dichlorobenzene	U	U	U	U	U	U	U	U	U	----
1,4-Dichlorobenzene	U	U	U	U	U	U	U	U	U	----
1,2-Dichlorobenzene	U	U	U	U	U	U	U	U	U	----
Naphthalene	U	U	U	U	U	U	U	U	U	5 ST
Total VOCs	0	5	2	0	37	81	7040	958	1223	----
Total VOC TICs	0	0	0	0	0	1150	12770	0	0	----

QUALIFIERS:
U: Compound analyzed for but not detected
B: Compound found in the blank as well as the sample
J: Compound found at a concentration below the CRDL, value estimated
D: Value is a result of analysis with a dilution factor of 20.0
D*: Value is a result of analysis with a dilution factor of 10.0
D**: Value is a result of analysis with a dilution factor of 5.0
U*: Result qualified as non-detect based upon validation criteria

NOTES:
*: Value pertains to cis-1,2 Dichloroethene and trans-1,2 Dichloroethene individually
**: Value pertains to the sum of the isomers
GV: Guidance Value
ST: Standard
----: Not established

[box] Indicates value exceeds NYSDEC Class GA groundwater standard or guidance value.

TABLE 4 (continued)
TAPPAN TERMINAL SITE
SUPPLEMENTAL REMEDIAL INVESTIGATION
DIRECT PUSH GROUNDWATER SAMPLE RESULTS - NOVEMBER 1999
VOLATILE ORGANIC COMPOUNDS BY MOBILE LAB GC/MS

Sample Identification	SR2-E130	SR3-W180	SR3-W140	SR3-W60	SR3-E14	SR3-E41	SR3-E90	SR4-W170	SR4-W40	NYSDEC Class GA Groundwater Standards
Date of Collection	11/12/99	11/12/99	11/12/99	11/11/99	11/10/99	11/10/99	11/12/99	11/12/99	11/11/99	
Dilution Factor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Units	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
Dichlorodifluoromethane	U	U	U	U	U	U	U	U	U	----
Chloromethane	U	U	U	U	U	U	U	U	U	5 ST
Vinyl Chloride	U	U	U	U	U	U	U	U	U	2 ST
Bromomethane	U	U	U	U	U	U	U	U	U	5 ST
Chloroethane	U	U	U	U	U	U	U	U	U	5 ST
Ethyl Ether	U	U	U	U	U	U	U	19	U	----
tert-Butyl-Methyl-Ether	U	U	U	U	U	U	U	U	U	----
Trichlorofluoromethane	U	U	U	U	U	U	U	U	U	----
Acrolein	U	U	U	U	U	U	U	U	U	----
Acrylonitrile	U	U	U	U	U	U	U	U	U	----
1,1-Dichloroethene	U	U	U	U	2.2 J	U	U	U	U	5 ST
Carbon Disulfide	U	U	U	U	U	U	U	U	U	----
Acetone	31	U	U	U	36	**110**	U	U	U	50GV
Methylene Chloride	U	U	U	**13 JB**	U	U	U	U	**30 JB**	5 ST
trans 1,2-Dichloroethene	U	U	U	U	3.8 J	U	U	U	U	----
cis 1,2-Dichloroethene	U	U	U	U	240 D*	U	U	U	U	----
1,1-Dichloroethane	U	U	U	U	U	U	U	U	U	5 ST
Chloroform	U	U	U	U	**11**	U	5.0 J	U	U	7 ST
1,2-Dichloroethane	U	U	U	U	U	U	U	U	U	0.6 ST
2-Butanone	U	U	U	U	U	U	U	U	U	50GV
1,1,1-Trichloroethane	U	U	U	U	U	U	U	U	U	5 ST
Carbon Tetrachloride	U	U	U	U	U	U	U	U	U	5 ST
Benzene	U	**1.6 J**	**8.3**	U	**2.7 J**	**1.4 J**	**2.0 J**	U	U	1 ST
Trichloroethene	U	U	U	U	**110**	U	U	U	U	5 ST
1,2-Dichloropropane	U	U	U	U	U	U	U	U	U	1 ST
Bromodichloromethane	U	U	U	U	U	U	U	U	U	50GV
cis-1,3-Dichloropropene	U	U	U	U	U	U	U	U	U	0.4 ST **
trans-1,3-Dichloropropene	U	U	U	U	U	U	U	U	U	0.4 ST **
1,1,2-Trichloroethane	U	U	U	U	U	U	U	U	U	1 ST
Dibromochloromethane	U	U	U	U	U	U	U	U	U	50GV
Bromoform	U	U	U	U	U	U	U	U	U	50GV
4-Methyl-2-Pentanone	U	U	U	U	U	U	U	U	U	----
Toluene	U	U	U	U	U	U	1.7 J	U	**130**	5 ST
Tetrachloroethene	2.1 J	U	U	U	**21**	U	U	U	U	5 ST
2-Hexanone	U	U	U	U	U	U	U	U	U	50GV
Chlorobenzene	**12**	**120**	**960 D***	**680**	**640 D***	**70**	**14**	2.1 J	**960**	5 ST
Ethylbenzene	U	U	U	U	U	U	U	U	U	5 ST
M&P Xylene	U	U	U	U	U	U	U	U	U	----
O Xylene	U	U	U	U	U	U	U	U	U	----
Styrene	U	U	U	U	U	U	U	U	U	5 ST
1,1,2,2-Tetrachloroethane	U	U	U	U	U	U	U	U	U	5 ST
1,3-Dichlorobenzene	U	U	U	U	U	U	U	U	U	----
1,4-Dichlorobenzene	U	U	U	U	U	U	U	U	U	----
1,2-Dichlorobenzene	U	U	U	U	U	U	U	U	U	----
Naphthalene	U	U	U	U	U	U	U	U	**650**	5 ST
Total VOCs	45	122	968	693	1067	181	23	21	1770	----
Total VOC TICs	11	465	0	0	0	0	0	0	187	----

QUALIFIERS:
U: Compound analyzed for but not detected
B: Compound found in the blank as well as the sample
J: Compound found at a concentration below the CRDL, value estimated
D: Value is a result of analysis with a dilution factor of 20.0
D*: Value is a result of analysis with a dilution factor of 10.0
D**: Value is a result of analysis with a dilution factor of 5.0
U*: Result qualified as non-detect based upon validation criteria

NOTES:
*: Value pertains to cis-1,2 Dichloroethene and trans-1,2 Dichloroethene individually
**: Value pertains to the sum of the isomers
GV: Guidance Value
ST: Standard
----: Not established

[box] Indicates value exceeds NYSDEC Class GA groundwater standard or guid: Indicates value exceeds NYSDEC Class GA

TABLE 4 (continued)
TAPPAN TERMINAL SITE
SUPPLEMENTAL REMEDIAL INVESTIGATION
DIRECT PUSH GROUNDWATER SAMPLE RESULTS - NOVEMBER 1999
VOLATILE ORGANIC COMPOUNDS BY MOBILE LAB GC/MS

Sample Identification	SR4-E20	SR4-E40	SR5-W115	SR5-W50	SR5-E12	SR5-E30	SR6-W5	NYSDEC Class GA Groundwater Standards
Date of Collection	11/09/99	11/09/99	11/12/99	11/11/99	11/11/99	11/10/99	11/11/99	
Dilution Factor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Units	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
Dichlorodifluoromethane	U	U	U	U	U	U	U	----
Chloromethane	U	U	U	U	U	U	U	5 ST
Vinyl Chloride	U	U	U	U	U	U	U	2 ST
Bromomethane	U	U	U	U	U	U	U	5 ST
Chloroethane	U	U	U	U	U	U	U	5 ST
Ethyl Ether	U	U	U	U	U	U	290	----
tert-Butyl-Methyl-Ether	U	U	U	U	U	U	U	----
Trichlorofluoromethane	U	U	U	U	U	U	U	----
Acrolein	U	U	U	U	U	U	U	----
Acrylonitrile	U	U	U	U	U	U	U	----
1,1-Dichloroethene	U	U	U	U	U	U	U	5 ST
Carbon Disulfide	U	U	U	U	U	U	U	----
Acetone	U	U	**68**	U	U	U	U	50GV
Methylene Chloride	U	U	**7.9 JB**	**26 JB**	U	**26 J**	**31 JB**	5 ST
trans 1,2-Dichloroethene	U	U	U	U	U	U	U	----
cis 1,2-Dichloroethene	U	U	U	U	U	U	U	----
1,1-Dichloroethane	U	U	U	U	U	U	U	5 ST
Chloroform	U	U	U	U	U	U	U	7 ST
1,2-Dichloroethane	U	U	U	U	U	U	U	0.6 ST
2-Butanone	U	U	U	U	U	U	U	50GV
1,1,1-Trichloroethane	U	U	U	U	U	U	U	5 ST
Carbon Tetrachloride	U	U	U	U	U	U	U	5 ST
Benzene	U	U	**14 J**	**190**	**18 J**	U	U	1 ST
Trichloroethene	U	U	U	U	U	U	U	5 ST
1,2-Dichloropropane	U	U	U	U	U	U	U	1 ST
Bromodichloromethane	U	U	U	U	U	U	U	50GV
cis-1,3-Dichloropropene	U	U	U	U	U	U	U	0.4 ST **
trans-1,3-Dichloropropene	U	U	U	U	U	U	U	0.4 ST **
1,1,2-Trichloroethane	U	U	U	U	U	U	U	1 ST
Dibromochloromethane	U	U	U	U	U	U	U	50GV
Bromoform	U	U	U	U	U	U	U	50GV
4-Methyl-2-Pentanone	U	U	U	U	U	U	U	----
Toluene	1.2 J	U	U	U	U	U	U	5 ST
Tetrachloroethene	U	U	U	U	U	U	U	5 ST
2-Hexanone	U	U	U	U	U	U	U	50GV
Chlorobenzene	**12**	U	**380**	**2900 D****	**46**	**87**	**180**	5 ST
Ethylbenzene	U	U	U	**12 J**	U	U	U	5 ST
M&P Xylene	U	U	U	U	U	U	U	----
O Xylene	U	U	U	23 J	U	U	U	----
Styrene	U	U	U	U	U	U	U	5 ST
1,1,2,2-Tetrachloroethane	U	U	U	U	U	U	U	5 ST
1,3-Dichlorobenzene	U	U	U	22 J	U	U	U	----
1,4-Dichlorobenzene	U	U	8.9 J	66	U	U	U	----
1,2-Dichlorobenzene	U	U	9.1 J	110	U	U	U	----
Naphthalene	**180**	**30**	U	**36 J**	U	U	U	5 ST
Total VOCs	193	30	488	3385	64	113	501	----
Total VOC TICs	13.7	0	0	0	0	25400	5980	----

QUALIFIERS:
U: Compound analyzed for but not detected
B: Compound found in the blank as well as the sample
J: Compound found at a concentration below the CRDL, value estimated
D: Value is a result of analysis with a dilution factor of 20.0
D*: Value is a result of analysis with a dilution factor of 10.0
D**: Value is a result of analysis with a dilution factor of 5.0
U*: Result qualified as non-detect based upon validation criteria

NOTES:
*: Value pertains to cis-1,2 Dichloroethene and trans-1,2 Dichloroethene individually
**: Value pertains to the sum of the isomers
GV: Guidance Value
ST: Standard
----: Not established

[box] Indicates value exceeds NYSDEC Class GA groundwater standard or guidance value.

TABLE 5
TAPPAN TERMINAL SITE
SUPPLEMENTAL REMEDIAL INVESTIGATION
DIRECT PUSH SUBSURFACE SOIL SAMPLE RESULTS - NOVEMBER 1999
LABORATORY METHOD COMPARISON

ample Identification	SB3-S50 (soil)			SB8-N12 (soil 2'-4')			SR1-E77 (soil 2'-5')			NYSDEC Recommended Soil Clean-Up Objective
lethod	Mobile GC	Mobile GC/MS	Fixed GC/MS	Mobile GC	Mobile GC/MS	Fixed GC/MS	Mobile GC	Mobile GC/MS	Fixed GC/MS	
Units	(ug/l)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Dichlorodifluoromethane	--	U	--	--	U	--	--	U	--	----
hloromethane	--	U	U	--	U	U	--	U	U	----
inyl Chloride	--	U	U	--	U	21	--	U	U	200
Bromomethane	--	U	U	--	U	U	--	U	U	----
Chloroethane	--	U	U	--	U	U	--	U	U	1,900
thyl Ether	--	1100	--	--	U	--	--	U	--	----
ert-Butyl-Methyl-Ether	--	U	--	--	U	--	--	U	--	----
richlorofluoromethane	--	U	--	--	U	--	--	U	--	----
Acrolein	--	U	--	--	U	--	--	U	--	----
Acrylonitrile	--	U	--	--	U	--	--	U	--	----
1,1-Dichloroethene	--	U	U	U	U	U	U	U	U	400
arbon Disulfide	--	U	U	--	U	3 J	--	U	U	2,700
Acetone	--	U	130 B	--	200 E	59 B	--	150	74 B	200
Methylene Chloride	--	260 JB	10 J	--	5.5 JB	7 J	--	28 JB	7 J	100
rans 1,2-Dichloroethene	--	U	--	--	U	--	--	U	--	300*
s 1,2-Dichloroethene	--	U	U	--	4 J	3 *J	--	U	U	300*
1-Dichloroethane	--	U	U	--	U	U	--	U	U	200
Chloroform	--	U	U	--	U	U	--	U	U	300
1,2-Dichloroethane	--	U	U	--	U	U	--	U	U	100
-Butanone	--	U	11 J	--	U	11 J	--	U	U	300
1,1-Trichloroethane	--	U	U	--	U	U	--	U	U	800
arbon Tetrachloride	--	U	U	--	U	U	--	U	U	600
Benzene	--	U	U	U	U	U	U	U	U	60
Trichloroethene	--	U	U	U	U	1 J	U	U	U	700
2-Dichloropropane	--	U	U	--	U	U	--	U	U	----
romodichloromethane	--	U	U	--	U	U	--	U	U	----
cis-1,3-Dichloropropene	--	U	U	--	U	U	--	U	U	----
trans-1,3-Dichloropropene	--	U	U	--	U	U	--	U	U	----
1,2-Trichloroethane	--	U	U	--	U	U	--	U	U	----
ibromochloromethane	--	U	U	--	U	U	--	U	U	----
romoform	--	U	U	--	U	U	--	U	U	----
4-Methyl-2-Pentanone	--	U	U	--	U	U	--	U	U	1,000
Toluene	--	150 J	U	U	U	U	U	U	U	1,500
etrachloroethene	--	U	2 J	--	U	4 J	--	U	16	1,400
-Hexanone	--	U	U	--	U	U	--	U	U	----
Chlorobenzene	--	1200	2 J	U	U	U	U	39	4 J	1,700
Ethylbenzene	--	U	U	--	U	U	--	U	U	5,500
M&P Xylene	--	U	--	--	U	--	--	U	--	1,200**
Xylene	--	U	U	--	U	U	--	U	U	1,200**
tyrene	--	U	U	--	U	U	--	U	U	----
1,1,2,2-Tetrachloroethane	--	U	U	--	U	U	--	U	U	600
1,3-Dichlorobenzene	--	U	--	--	U	--	--	U	--	----
4-Dichlorobenzene	--	U	--	--	U	--	--	U	--	----
2-Dichlorobenzene	--	U	--	--	U	--	--	U	--	----
aphthalene	--	U	--	--	U	--	--	82	--	----

QUALIFIERS:
U: Compound analyzed for but not detected
J: Compound found at aconcentration below the MDL, value estimated
: Result taken from reanalysis at dilution
B: Compound found in the blank as well as the sample
E: Value exceeds calibration standard

NOTES:
*: Value pertains to the sum of cis-1,2 Dichloroethene and trans-1,2 Dichloroethene
**: Value pertains to the sum of the xylene isomers
--: Compound not analyzed for using this method

-Target compunds for this investigation
-Indincates exceeds NYSDEC recommended soil clean-up objective.

TABLE 7
TAPPAN TERMINAL SITE
REMEDIAL INVESTIGATION AND FEASIBILITY STUDY
SUPPLEMENTAL SURFACE SOIL SAMPLE RESULTS - NOVEMBER 1999
PESTICIDE/PCBs

Sample Identification	P-1*	P-2*	P-3*	P-4*	P-5*	P-6*	P-7	P-8*	P-9	P-10*	P-11	P-12	Contract Required Detection Limit	NYSDEC Recommended Soil Clean-Up Objective
Sample Depth	0-3"	0-3"	0-3"	0-3"	0-3"	0-3"	0-3"	0-3"	0-3"	0-3"	0-3"	0-3"		
Date of Collection	11/11/99	11/11/99	11/11/99	11/11/99	11/11/99	11/11/99	11/11/99	11/11/99	11/11/99	11/11/99	11/11/99	11/11/99		
Dilution Factor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
Percent Moisture	13	18	18	13	22	16	8	23	13	14	44	52		
Units	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Aroclor-1016	U	U	U	U	U	U	U	U	U	U	U	U	1.0	1000*
Aroclor-1221	U	U	U	U	U	U	U	U	U	U	U	U	2.0	1000*
Aroclor-1232	U	U	U	U	U	U	U	U	U	U	U	U	1.0	1000*
Aroclor-1242	U	U	U	U	U	U	U	U	U	U	U	U	1.0	1000*
Aroclor-1248	U	U	U	U	U	U	U	U	U	U	U	U	1.0	1000*
Aroclor-1254	U	U	U	U	U	U	U	540	U	370	1500	2000	1.0	1000*
Aroclor-1260	U	90 P	690	230	120	U	U	1,400	230	160 P	2400 P	3000 P	1.0	1000*
Total PCBs	0	90	690	230	120	0	0	1,940	230	530	3900	5000		1000*

QUALIFIERS:

U: Compound analyzed for but not detected

J: Compound found at a concentration below the CRDL, value estimated

P: Greater than 25% difference for detected concentrations between the two GC columns

D: Value is a result of analysis with a dilution factor of 5.0

NOTES:

* Sample collected beneath asphalt surface

[box] Indicates value exceeds NYSDEC recommended soil clean-up objective

Appendix B

APPENDIX B

DETAILED COSTS ESTIMATES

Alternative S2
Tappan Terminal Site
Institutional Controls
Cost Estimate

Capital Costs

Item	Quantity	Units	Unit Cost	Total
Fence	1,150	FT	$20.00	$23,000
Estimated Capital Cost				$23,000

Contingency and Engineering Fees

Contingency allowance (15%)	$3,000
Engineering fees (20%)*	$5,000
Estimated Contingency and Engineering Fees	$8,000
TOTAL ESTIMATED CAPITAL COST	$31,000

Annual Maintenance Costs
Fence

Site inspection	2	Mandays	$600.00	$1,200
Miscellaneous repairs	-	Lump Sum	$1,000.00	$1,000
Annual cost				$2,200
Present worth of annual operation & maintenance cost for 30 yrs (i=5%)				$34,000

Remedial Alternative S2
Total Estimated Costs **$65,000**

* Includes design and construction inspection.

Alternative S3
Tappan Terminal Site
Part 360 Cap (Mobil Property) and Pavement Cap (Uhlich Property)
Cost Estimate

Item				
Capital Costs	**Quantity**	**Units**	**Unit Cost**	**Total**
Mobilization/demobilization*	-	Lump Sum	$300,000.00	$300,000
Site Preparation				
Clearing and grubbing	8	Acres	$7,000.00	$54,000
Removal of abandoned surface and subsurface structures	60	CY	$110.00	$7,000
Transportation and disposal of concrete	120	CY	$50.00	$6,000
Geomembrane Cap				
Buy/haul/place contour grading material	36,000	CY	$13.00	$468,000
Buy/haul/place 60 mil HDPE geomembrane	37,000	SQ YD	$6.00	$222,000
Buy/haul/place geocomposite	37,000	SQ YD	$5.00	$185,000
Buy/haul/place barrier protection layer	25,000	CY	$15.00	$375,000
Buy/haul/place 6" vegetative growth medium	6,000	CY	$17.00	$102,000
Seed, fertilize and mulch	37,000	SQ YD	$1.00	$37,000
Anchor trench material	350	CY	$7.00	$2,000
Pavement Cap				
Binder coarse (2")	12,000	SQ YD	$3.00	$36,000
Wearing coarse (3")	12,000	SQ YD	$7.00	$84,000
Storm Water Drainage System				
Diversion swale/berm	1,850	FT	$11.00	$20,000
Off-site conveyance piping	1,850	FT	$150.00	$278,000
		Estimated Capital Cost		**$2,176,000**
Contingency and Engineering Fees				
Contingency allowance (15%)				$326,000
Engineering fees (15%)**				$326,000
		Estimated Contingency and Engineering Fees		$652,000
		TOTAL ESTIMATED CAPITAL COST		**$2,828,000**

Alternative S3
Tappan Terminal Site
Part 360 Cap (Mobil Property) and Pavement Cap (Uhlich Property)
Cost Estimate (continued)

Annual Operating and Maintenance Costs				
Part 360 Cap				
Site inspection	4	Mandays	$600.00	$2,400
Miscellaneous site work (including swale maintenance)	10	Mandays	$600.00	$6,000
Vegetation maintenance and site materials	-	Lump Sum	$5,000.00	$5,000
	Annual cost			$13,400
	Present worth of annual operation & maintenance cost for 30 yrs (i=5%)			$206,000
Pavement Cap				
Site inspection	2	Mandays	$600.00	$1,200
Miscellaneous site work	2	Mandays	$600.00	$1,200
Patching and repair	1,000	SQ YD	$7.00	$7,000
	Annual cost			$9,400
	Present worth of annual operation & maintenance cost for 30 yrs (i=5%)			$145,000

Remedial Alternative S3 Total Estimated Costs	**$3,179,000**

*Includes bonds, insurance, temporary facilities, pre-construction submittals and as built drawings
** Includes design and construction inspection.

Alternative S4
Tappan Terminal Site
Soil Cover (Mobil Property) and Pavement Cap (Uhlich Property)
Cost Estimate

Item	Quantity	Units	Unit Cost	Total
Capital Costs				
Mobilization/demobilization*	-	Lump Sum	$300,000.00	$300,000
Site Preparation				
Clearing and grubbing	8	Acres	$7,000.00	$54,000
Soil Cover				
Buy/haul/place 18" soil cover	19,000	CY	$13.00	$247,000
Buy/haul/place 6" vegetative growth medium	6,000	CY	$17.00	$102,000
Seed, fertilize and mulch	37,000	SQ YD	$1.00	$37,000
Storm Water Drainage System				
Diversion swale/berm	1,850	FT	$11.00	$20,000
Off-site conveyance piping	1,850	FT	$150.00	$278,000
Pavement Cap				
Binder coarse (2")	12,000	SQ YD	$3.00	$36,000
Wearing coarse (3")	12,000	SQ YD	$7.00	$84,000
	Estimated Capital Cost			**$1,158,000**
Contingency and Engineering Fees				
Contingency allowance (15%)				$174,000
Engineering fees (15%)**				$174,000
Estimated Contingency and Engineering Fees				$348,000
TOTAL ESTIMATED CAPITAL COST				**$1,506,000**

Alternative S4
Tappan Terminal Site
Soil Cover (Mobil Property) and Pavement Cap (Uhlich Property)
Cost Estimate (continued)

Annual Operating and Maintenance Costs				
Cover				
Site inspection	4	Mandays	$600.00	$2,400
Vegetation maintenance and site materials	-	Lump Sum	$3,000.00	$3,000
Miscellaneous site work (including swale maintenance)	10	Mandays	$600.00	$6,000
	Annual cost			$11,400
	Present worth of annual operation & maintenance cost for 30 yrs (i=5%)			$175,000
Pavement Cap				
Site inspection	2	Mandays	$600.00	$1,200
Miscellaneous site work	2	Mandays	$600.00	$1,200
Patching and repair	1,000	SQ YD	$7.00	$7,000
	Annual cost			$9,400
	Present worth of annual operation & maintenance cost for 30 yrs (i=5%)			$145,000

Remedial Alternative S4
Total Estimated Costs **$1,826,000**

*Includes bonds, insurance, temporary facilities, pre-construction submittals and as built drawings
** Includes design and construction inspection.

Alternative S5
Tappan Terminal Site
Partial Excavation and Off-site Disposal(Mobil and Uhlich Properties),
Soil Cover(Mobil Property) and Pavement Cap (Uhlich Property)
Cost Estimate

Item	Quantity	Units	Unit Cost	Total
Capital Costs				
Mobilization/demobilization*	-	Lump Sum	$300,000.00	$300,000
Site Preparation				
Clearing and grubbing	8	Acres	$7,000.00	$54,000
Excavation of Contaminated Soil				
Excavation of soil	7,200	CY	$7.00	$50,000
Transportation and disposal of non hazardous waste	7,200	Ton	$60.00	$432,000
Placement of backfill	6,500	CY	$13.00	$85,000
Soil Cover				
Buy/haul/place 18" soil cover	19,000	CY	$13.00	$247,000
Buy/haul/place 6" vegetative growth medium	6,000	CY	$17.00	$102,000
Seed, fertilize and mulch	37,000	SQ YD	$1.00	$37,000
Pavement Cap				
Binder coarse (2")	15,000	SQ YD	$3.00	$45,000
Wearing coarse (3")	15,000	SQ YD	$7.00	$105,000
		Estimated Capital Cost		**$1,457,000**
Contingency and Engineering Fees				
Contingency allowance (15%)				$219,000
Engineering fees (15%)**				$219,000
Estimated Contingency and Engineering Fees				$438,000
TOTAL ESTIMATED CAPITAL COST				**$1,895,000**

Alternative S5
Tappan Terminal Site
Partial Excavation and Off-site Disposal(Mobil and Uhlich Properties),
Soil Cover(Mobil Property) and Pavement Cap (Uhlich Property)
Cost Estimate (continued)

Annual Operating and Maintenance Costs				
Cover				
Site inspection	4	Mandays	$600.00	$2,400
Vegetation maintenance and site materials	-	Lump Sum	$3,000.00	$3,000
Miscellaneous site work (including swale maintenance)	10	Mandays	$600.00	$6,000
	Annual cost			$11,400
	Present worth of annual operation & maintenance cost for 30 yrs (i=5%)			$175,000
Pavement Cap				
Site inspection	2	Mandays	$600.00	$1,200
Miscellaneous site work	2	Mandays	$600.00	$1,200
Patching and repair	1,000	SQ YD	$7.00	$7,000
	Annual cost			$9,400
	Present worth of annual operation & maintenance cost for 30 yrs (i=5%)			$145,000
	Remedial Alternative S5 Total Estimated Costs			**$2,215,000**

*Includes bonds, insurance, temporary facilities, pre-construction submittals and as built drawings
** Includes design and construction inspection.

Alternative S6
Tappan Terminal Site
Complete Excavation and Off-site Disposal (Mobil Property), Partial Excavation and Off-site Disposal(Uhlich Property) and Pavement Cap (Uhlich Property)
Cost Estimate

Item	Quantity	Units	Unit Cost	Total
Capital Costs				
Mobilization/demobilization*	-	Lump Sum	$300,000.00	$300,000
Site Preparation				
Removal of abandoned surface and subsurface structures	800	CY	$110.00	$88,000
Transportation and disposal of concrete	1,600	CY	$50.00	$80,000
Excavation of Contaminated Soil				
Excavation of soil	67,000	CY	$7.00	$469,000
Transportation and disposal of non hazardous waste	67,000	Ton	$60.00	$4,020,000
Buy/haul/place backfill	61,000	CY	$13.00	$793,000
Buy/haul/place 6" vegetative growth medium	6,000	CY	$17.00	$102,000
Seed, fertilize and mulch	37,000	SQ YD	$1.00	$37,000
Pavement Cap				
Binder coarse (2")	15,000	SQ YD	$3.00	$45,000
Wearing coarse (3")	15,000	SQ YD	$7.00	$105,000
		Estimated Capital Cost		**$6,039,000**
Contingency and Engineering Fees				
Contingency allowance (10%)				$604,000
Engineering fees (15%)**				$906,000
Estimated Contingency and Engineering Fees				$1,510,000
TOTAL ESTIMATED CAPITAL COST				**$7,549,000**

Alternative S6
Tappan Terminal Site
Complete Excavation and Off-site Disposal (Mobil Property), Partial Excavation and Off-site Disposal(Uhlich Property) and Pavement Cap (Uhlich Property)
Cost Estimate(continued)

Annual Operating and Maintenance Costs
Pavement Cap

Site inspection	2	Mandays	$600.00	$1,200
Miscellaneous site work	2	Mandays	$600.00	$1,200
Patching and repair	1,000	SQ YD	$7.00	$7,000
	Annual cost			$9,400
	Present worth of annual operation & maintenance cost for 30 yrs (i=5%)			$145,000

Remedial Alternative S6 Total Estimated Costs	**$7,694,000**

*Includes bonds, insurance, temporary facilities, pre-construction submittals and as built drawings
** Includes design and construction inspection.

Alternative G1
Tappan Terminal Site
No Action with Long-term Groundwater Monitoring
Cost Estimate

Item	Quantity	Units	Unit Cost	Total
Groundwater Monitoring Costs Per Event				
Groundwater sampling	2	Mandays	$600	$1,200
Purge water disposal	1	Drums	$200	$200
Equipment, materials and supplies	-	Lump Sum	$1,000	$1,000
Sample analysis*	8	Samples	$500	$4,000
	Estimated per event monitoring costs			$6,400
	Present worth of annual groundwater monitoring (30 yrs, i=5%)**			$330,000
	Remedial Alternative G1 Total Estimated Costs			**$330,000**

*Sample analysis includes full TCL+30 parameters
**Sampling frequency includes 4 times per year for the first 15 years, 2 times per year for the next 15 years.

Assume annual sampling instead.

Alternative G2
Tappan Terminal Site
Air Sparging and Soil Vapor Extraction
Cost Estimate

Item	Quantity	Units	Unit Cost	Total
Capital Costs				
Mobilization/demobilization*	-	Lump Sum	$125,000.00	$125,000
Placement of Liner				
Buy/haul/place 40 mil HDPE geomembrane	6,500	SQ YD	$5.00	$33,000
Air Sparging and Soil Vapor Extraction				
Installation of air sparging wells and soil vapor extraction laterals	-	Lump Sum	$235,000.00	$235,000
Installation of air sparging and soil vapor extraction system (including compressor, blower, and carbon treatment system)	-	Lump Sum	$275,000.00	$275,000
System building	-	Lump Sum	$20,000.00	$20,000
Initial startup and testing	-	Lump Sum	$25,000.00	$25,000
Confirmatory sampling	-	Lump Sum	$35,000.00	$35,000
Pilot test	-	Lump Sum	$50,000.00	$50,000
		Estimated Capital Cost		**$798,000**
Contingency and Engineering Fees				
Contingency allowance (15%)				$120,000
Engineering fees (15%)**				$120,000
Estimated Contingency and Engineering Fees				$240,000
TOTAL ESTIMATED CAPITAL COST				**$1,038,000**

Alternative G2
Tappan Terminal Site
Soil Vapor Extraction and Air Sparging
Cost Estimate (continued)

Annual Operating and Maintenance Costs

Air Sparging and Soil Vapor Extraction System

AS and SVE system O&M (includes service and power costs, sampling and monitoring, and carbon replacement)	-	Lump Sum	$225,000.00	$225,000
	Annual cost			
	Present worth of annual operation & maintenance cost for 5 yrs (i=5%)			$974,000

Groundwater Monitoring Costs Per Event

Groundwater sampling	2	Mandays	$600	$1,200
Purge water disposal	1	Drums	$200	$200
Equipment, materials and supplies	-	Lump Sum	$1,000	$1,000
Sample analysis***	8	Samples	$500	$4,000
	Estimated per event monitoring costs			$6,400
	Present worth of annual groundwater monitoring (30 yrs, i=5%)****			$171,000

Remedial Alternative G2
Total Estimated Costs **$2,183,000**

*Includes bonds, insurance, temporary facilities, pre-construction submittals and as built drawings
** Includes design and construction inspection.
***Sample analysis includes full TCL+30 parameters
****Sampling frequency includes 4 times per year for the first 5 years, 2 times per year for the next 5 years and 1 time per year for the next 5 years.

Alternative G3
Tappan Terminal Site
Hydraulic Barrier, Groundwater Extraction and Treatment and Discharge to the Hudson River
Cost Estimate

Item	Quantity	Units	Unit Cost	Total
Capital Costs				
Mobilization/demobilization*	-	Lump Sum	$200,000.00	$200,000
Groundwater Extraction and Treatment System				
Installation of extraction wells and pump system (includes test borings, well construction, development, well development water disposal, tests, pumps and vaults)	-	Lump Sum	$200,000.00	$200,000
Aeration tank and blowers	-	Lump Sum	$200,000.00	$200,000
Thermal oxidizer	-	Lump Sum	$75,000.00	$75,000
Rapid mix/coag/plate settler	-	Lump Sum	$110,000.00	$110,000
Aeration tower and blowers	-	Lump Sum	$70,000.00	$70,000
Granular activated carbon	-	Lump Sum	$60,000.00	$60,000
Piping	-	Lump Sum	$75,000.00	$75,000
Electric	-	Lump Sum	$100,000.00	$100,000
Building	-	Lump Sum	$200,000.00	$200,000
Miscellaneous equipment	-	Lump Sum	$50,000.00	$50,000
Slurry Wall	1,100	Lineal Feet	$20.00	$22,000
		Estimated Capital Cost		**$1,362,000**
Contingency and Engineering Fees				
Contingency allowance (15%)				$204,000
Engineering fees (20%)**				$272,000
Estimated Contingency and Engineering Fees				$476,000
TOTAL ESTIMATED CAPITAL COST				**$1,838,000**

Alternative G3
Tappan Terminal Site
Hydraulic Barrier, Groundwater Extraction and Treatment and Discharge to the Hudson River
Cost Estimate(continued)

Annual Operating and Maintenance Costs				
Groundwater Extraction and Treatment System				
Extraction well pumps (includes service and power costs)	-	Lump Sum	$10,000.00	$10,000
Treatment system (including service and power)	-	Lump Sum	$10,000.00	$10,000
Residuals disposal	24,000	Gallons	$1.00	$24,000
System O&M labor	2,080	Hours	$50.00	$104,000
	Annual cost			$148,000
	Present worth of annual operation & maintenance cost for 15 yrs (i=5%)			$1,536,000
Discharge Monitoring Costs Per Event				
Discharge sampling	1	Mandays	$600	$600
Equipment, materials and supplies	-	Lump Sum	$100	$100
Sample analysis***	1	Samples	$500	$500
	Estimated per event monitoring costs			$1,200
	Present worth of annual discharge monitoring (15 yrs, i=5%)****			$18,000
Groundwater Monitoring Costs Per Event				
Groundwater sampling	2	Mandays	$600	$1,200
Purge water disposal	1	Drums	$200	$200
Equipment, materials and supplies	-	Lump Sum	$1,000	$1,000
Sample analysis***	8	Samples	$500	$4,000
	Estimated per event monitoring costs			$6,400
	Present worth of annual groundwater monitoring (30 yrs, i=5%)*****			$277,000
	Remedial Alternative G3 Total Estimated Costs			**$3,669,000**

*Includes bonds, insurance, temporary facilities, pre-construction submittals and as built drawings

** Includes design and construction inspection.

***Sample analysis includes full TCL+30 parameters

****Sampling frequency includes 12 times per year

****Sampling frequency includes 4 times per year for the first 10 years, 2 times per year for the next 10 years and 1 time per year for the next 10 years.

Alternative G4
Tappan Terminal Site
In-situ Chemical Oxidation
Cost Estimate

Item	Quantity	Units	Unit Cost	Total
Capital Costs				
Mobilization/demobilization*	-	Lump Sum	$50,000.00	$50,000
Chemical Oxidation System				
Pilot test	-	Lump Sum	$100,000.00	$100,000
Project design	-	Lump Sum	$10,000.00	$10,000
Injector fabrication and install including drilling	-	Lump Sum	$555,000.00	$555,000
Chemical injection program	-	Lump Sum	$275,000.00	$275,000
Reagents	-	Lump Sum	$265,000.00	$265,000
Project documentation	-	Lump Sum	$10,000.00	$10,000
Pre and post sampling	-	Lump Sum	$35,000.00	$35,000
		Estimated Capital Cost		**$1,300,000**
Contingency and Engineering Fees				
Contingency allowance (15%)				$195,000
Engineering fees (15%)**				$195,000
Estimated Contingency and Engineering Fees				$390,000
TOTAL ESTIMATED CAPITAL COST				**$1,690,000**

Alternative G4
Tappan Terminal Site
In-situ Chemical Oxidation
Cost Estimate (continued)

Annual Operating and Maintenance Costs

Groundwater Monitoring Costs Per Event

Groundwater sampling	2	Mandays	$600	$1,200
Purge water disposal	1	Drums	$200	$200
Equipment, materials and supplies	-	Lump Sum	$1,000	$1,000
Sample analysis***	8	Samples	$500	$4,000
	Estimated per event monitoring costs			$6,400
	Present worth of annual groundwater monitoring (30 yrs, i=5%)****			$171,000
	Remedial Alternative G4 Total Estimated Costs			**$1,861,000**

*Includes bonds, insurance, temporary facilities, pre-construction submittals and as built drawings

** Includes design and construction inspection.

***Sample analysis includes full TCL+30 parameters

****Sampling frequency includes 4 times per year for the first 5 years, 2 times per year for the next 5 years and 1 time per year for the next 5 years.

TAPPAN TERMINAL

FEASIBILITY STUDY

SUPPLEMENTAL COST ESTIMATES

December 2005

Alternative S2
Tappan Terminal site
Institutional Controls
Cost Estimate

Basis: Fencing

Item	Quantity	Units	Unit Cost	Total
Capital Costs				
Fencing	1150	LF	$20	$23,000
Contingency & Engineering Fees				
Contingency (15%)				$3,450
Engineering Fees (20%)				$4,600
Total Estimated Capital Cost				**$31,000**
Long Term Site Management				
Site Inspection and Annual Certification	2	mandays	$600	$1,200
Miscellaneous Repairs	1	lump sum	$1,000	$1,000
Subtotal				$2,200
Present Value - 30 yrs @ 5%				**$34,000**
Total Remedial Alternative Cost				**$65,000**

Alternative S3
Tappan Terminal site
Part 360 Landfill Cap
Cost Estimate

Basis: Part 360 landfill cap with a geomembrane barrier over the entire 15 acres of the site. Grading material as needed to achieve 2% slopes.

Item	Quantity	Units	Unit Cost	Total
Capital Costs				
Mobilization/Demobilization	1	Lump Sum	$300,000	$300,000
Site Preparation				
Clearing & Grubbing	8	Acres	$7,000	$56,000
Removal of abandoned structures	60	cu yds	$110	$6,600
Disposal of concrete	120	cu yds	$50	$6,000
Part 360 Cap				
Contour Grading Material	71,000	cu yds	$15	$1,065,000
Geomembrane (60 mil HDPE)	73,000	sq yds	$6	$438,000
Geocomposite	73,000	sq yds	$5	$365,000
18" barrier protection layer	36,500	cu yds	$15	$547,500
6" topsoil	12,200	cu yds	$25	$305,000
Seed, fertilize & mulch	73,000	sq yds	$1	$73,000
Storm Water Drainage System				
Diversion swale/berm	1,850	ft	$11	$20,350
Conveyance Piping	1,850	ft	$150	$277,500
Estimated Construction Cost				$3,459,950
Contingency & Engineering Fees				
Contingency (15%)				$518,993
Engineering Fees (15%)				$518,993
Environmental Easement				$1,000
Total Estimated Capital Cost				**$4,499,000**
Long Term Site Management				
Site Inspection and Annual Certification	4	mandays	$600	$2,400
Vegetation Maintenance	1	Lump Sum	$5,000	$5,000
Miscellaneous Site Work	10	mandays	$600	$6,000
Subtotal				$13,400
Present Value - 30 yrs @ 5%				**$206,000**
Total Remedial Alternative Cost				**$4,705,000**

Alternative S4
Tappan Terminal site
Soil Cover and Demarcation Layer
Cost Estimate

Basis: Existing pavement and foundations are sufficient for 4.8 acres of the Uhlich property. The remaining 10.2 acres of the site (Uhlich & Mobil properties) require a geogrid demarcation layer and a 6" bedding layer. The entire 15 acre site requires an additional 18" of fill and topsoil.

Item	Quantity	Units	Unit Cost	Total
Capital Costs				
Mobilization/Demobilization	1	Lump Sum	$300,000	$300,000
Site Preparation				
Clearing & Grubbing	8	Acres	$7,000	$56,000
Barrier and Soil Cover				
Bedding for Geogrid (6" soil)	8,200	cu yds	$15	$123,000
Geogrid	49,000	sq yds	$3	$147,000
12" general fill	24,300	cu yds	$15	$364,500
6" topsoil	12,200	cu yds	$25	$305,000
Seed, fertilize & mulch	73,000	sq yds	$1	$73,000
Storm Water Drainage System				
Diversion swale/berm	1,850	ft	$11	$20,350
Conveyance Piping	1,850	ft	$150	$277,500
Estimated Construction Cost				$1,666,350
Contingency & Engineering Fees				
Contingency (15%)				$249,953
Engineering Fees (15%)				$249,953
Environmental Easement				$1,000
Total Estimated Capital Cost				**$2,167,000**
Long Term Site Management				
Site Inspection and Annual Certification	4	mandays	$600	$2,400
Vegetation Maintenance	1	Lump Sum	$5,000	$5,000
Miscellaneous Site Work	10	mandays	$600	$6,000
Subtotal				$13,400
Present Value - 30 yrs @ 5%				**$206,000**
Total Remedial Alternative Cost				**$2,373,000**

Alternative S5
Tappan Terminal site
Excavation of Chlorobenzene, Petroleum and
Dye-Contaminated Soil and Installation of a Soil Cover System
Cost Estimate

Basis: Existing pavement and foundations are sufficient for 4.8 acres of the Uhlich property. The remaining 10.2 acres of the site (Uhlich & Mobil properties) require a geogrid contact barrier and a 6" bedding layer. The entire 15 acre site requires an additional 18" of fill and topsoil. Excavation includes 7000 cu yds of chlorobenzene contaminated soil and 100 cy yds of petroleum and dye-contaminated soil.

Item	Quantity	Units	Unit Cost	Total
Capital Costs				
Mobilization/Demobilization	1	Lump Sum	$300,000	$300,000
Site Preparation				
Clearing & Grubbing	8	Acres	$7,000	$56,000
Excavation of Contaminated Soil				
Excavation of Soil	7100	cu yds	$10	$71,000
Transportation and Disposal - Hazardous Waste	7800	tons	$150	$1,170,000
Backfill	7100	cu yds	$15	$106,500
Barrier and Soil Cover				
Bedding for Geogrid (6" soil)	8,200	cu yds	$15	$123,000
Geogrid	49,000	sq yds	$3	$147,000
12" general fill	24,300	cu yds	$15	$364,500
6" topsoil	12,200	cu yds	$25	$305,000
Seed, fertilize & mulch	73,000	sq yds	$1	$73,000
Storm Water Drainage System				
Diversion swale/berm	1,850	ft	$11	$20,350
Conveyance Piping	1,850	ft	$150	$277,500
Estimated Construction Cost				$3,013,850
Contingency & Engineering Fees				
Contingency (15%)				$452,078
Engineering Fees (15%)				$452,078
Environmental Easement				$1,000
Total Estimated Capital Cost				**$3,919,000**
Long Term Site Management				
Site Inspection and Annual Certification	4	mandays	$600	$2,400
Vegetation Maintenance	1	Lump Sum	$5,000	$5,000
Miscellaneous Site Work	10	mandays	$600	$6,000
Subtotal				$13,400
Present Value - 30 yrs @ 5%				**$206,000**
Total Remedial Alternative Cost				**$4,125,000**

Alternative S6
Tappan Terminal site
Soil Vapor Extraction, Excavation of Petroleum and Dye-Contaminated Soil, and Installation of a Soil Cover System
Cost Estimate

Basis: Excavation of 100 cubic yards of petroleum and dye-contaminated soil. Placement of geogrid over 10 acres of the site. Placement of a soil cover over the entire 15 acre site.

Item	Quantity	Units	Unit Cost	Total
Capital Costs				
Mobilization/Demobilization	1	lump sum	$300,000	$300,000
Site Preparation				
Clearing & Grubbing	8	Acres	$7,000	$56,000
Soil Vapor Extraction				
Surface air barrier	6500	sq yds	$5	$32,500
Installation of SVE laterals	1	lump sum	$150,000	$150,000
Installation of vapor extraction & treatment system	1	lump sum	$175,000	$175,000
System building	1	lump sum	$20,000	$20,000
Pilot test	1	lump sum	$25,000	$25,000
Startup and testing	1	lump sum	$25,000	$25,000
				$0
Excavation of Contaminated Soil				
Excavation of Soil	100	cu yds	$10	$1,000
Transportation and Disposal - Petroleum Waste	110	tons	$150	$16,500
Backfill	100	cu yds	$15	$1,500
Barrier and Soil Cover				
Bedding for Geogrid (6" soil)	8,200	cu yds	$15	$123,000
Geogrid	49,000	sq yds	$3	$147,000
12" general fill	24,300	cu yds	$15	$364,500
6" topsoil	12,200	cu yds	$25	$305,000
Seed, fertilize & mulch	73,000	sq yds	$1	$73,000
Storm Water Drainage System				
Diversion swale/berm	1,850	ft	$11	$20,350
Conveyance Piping	1,850	ft	$150	$277,500
Estimated Construction Cost				**$2,112,850**
Contingency & Engineering Fees				
Contingency (15%)				$316,928
Engineering Fees (15%)				$316,928
Environmental Easement				$1,000

Tappan Terminal
Alternative S6 (Cont.)

Total Estimated Capital Cost				**$2,748,000**
Operation and Maintenance Costs				
Vapor Extraction Operating and Maintenance Costs (includeins service & power costs, sampling & monitoring and carbon replacement)	1	lump sum	200,000	$200,000
Present Value - 5 yrs @ 5%				$865,800
Long Term Site Management				
Site Inspection and Annual Certification	4	mandays	$600	$2,400
Vegetation Maintenance	1	Lump Sum	$5,000	$5,000
Miscellaneous Site Work	2	mandays	$600	$1,200
Subtotal				$8,600
Present Value - 30 yrs @ 5%				$132,000
Total Operation, Maintenance and Site Management Costs				**$997,800**
Total Remedial Alternative Cost				**$3,746,000**

Alternative S7
Tappan Terminal site
Excavation of Fill above the Water Table
Cost Estimate

Basis: Excavation of 5 feet of contaminated soil across the entire 15 acres of the site.

Item	Quantity	Units	Unit Cost	Total
Capital Costs				
Mobilization/Demobilization	1	Lump Sum	$300,000	$300,000
Site Preparation				
Clearing & Grubbing	8	Acres	$7,000	$56,000
Excavation of Contaminated Soil				
Excavation of Soil	121,000	cu yds	$10	$1,210,000
Transportation and Disposal	7,800	tons	$150	$1,170,000
Transportation and Disposal - Non Hazardous Soils	125,200	tons	$70	$8,764,000
Backfill	121,000	cu yds	$15	$1,815,000
6" topsoil	12,200	cu yds	$25	$305,000
Seed, fertilize & mulch	73,000	sq yds	$1	$73,000
Estimated Construction Cost				$13,693,000
Contingency & Engineering Fees				
Contingency (10%)				$1,369,300
Engineering Fees (15%)				$2,053,950
Environmental Easement				$1,000
Total Estimated Capital Cost				**$17,117,000**
Long Term Site Management				
Site Inspection and Annual Certification	4	mandays	$600	$2,400
Vegetation Maintenance	1	Lump Sum	$5,000	$5,000
Miscellaneous Site Work	2	mandays	$600	$1,200
Subtotal				$8,600
Present Value - 30 yrs @ 5%				**$132,000**
Total Remedial Alternative Cost				**$17,249,000**

Alternative G1
Tappan Terminal site
No Action with Long-Term Groundwater Monitoring
Cost Estimate

Basis: Annual groundwater monitoring for 30 years

Item	Quantity	Units	Unit Cost	Total
Groundwater Monitoring Costs per Event				
Groundwater Sampling	2	man days	$600	$1,200
Purge water disposal	1	drum	$200	$200
Equipment, materials & supplies	1	lump sum	$1,000	$1,000
Sample analysis	8	samples	$500	$4,000
Subtotal				**$6,400**
Present Value - 30 yrs @ 5%	**15.37**			**$98,384**

Alternative G2
Tappan Terminal site
Air sparging with Soil Vapor Extraction
Cost Estimate

Basis: AS/SVE operation for 5 years, followed by annual groundwater monitoring for 30 years

Item	Quantity	Units	Unit Cost	Total
Mobilization/Demobilization	1	lump sum	$125,000	$125,000
Air Sparge & Soil Vapor Extraction				
Surface air barrier	6500	sq yds	$5	$32,500
Installation of AS wells and SVE laterals	1	lump sum	$235,000	$235,000
Installation of air sparging and vapor extraction & treatment system	1	lump sum	$275,000	$275,000
System building	1	lump sum	$20,000	$20,000
Pilot test	1	lump sum	$50,000	$50,000
Startup and testing	1	lump sum	$25,000	$25,000
Estimated Capital Cost				**$762,500**
Contingency & Engineering Fees				
Contingency (15%)				$114,375
Engineering Fees (15%)				$114,375
Total Estimated Capital Costs				**$991,250**
Operation and Maintenance Costs				
AS/SVE Operating and Maintenance Costs (includeins service & power costs, sampling & monitoring and carbon replacement)	1	lump sum	225,000	$225,000
Present Value - 5 yrs @ 5%				**$974,025**
Long-Term Groundwater Monitoring				
Groundwater Sampling	2	man days	$600	$1,200
Purge water disposal	1	drum	$200	$200
Equipment, materials & supplies	1	lump sum	$1,000	$1,000
Sample analysis	8	samples	$500	$4,000
Subtotal				**$6,400**
Present Value - 30 yrs @ 5%				**$98,000**
Total Remedial Alternative Cost				**$2,063,275**

Alternative G3
Tappan Terminal site
Hydraulic Barrier, Groundwater Extraction and Treatment with Discharge to the Hudson River
Cost Estimate

Basis: 15 Years of operation, quarterly monitoring years 1-10, semiannual monitoring years 10-20, annual monitoring years 20-30

Item	Quantity	Units	Unit Cost	Total
Mobilization/Demobilization	1	lump sum	$200,000	$200,000
ndwater Extraction and Treatment System				
Extraction wells and pumping system	1	lump sum	$200,000	$200,000
Aeration tanks & blowers	1	lump sum	$200,000	$200,000
Thermal oxidizer	1	lump sum	$75,000	$75,000
Rapix mix/coag/plate settler	1	lump sum	$110,000	$110,000
Aeration towers and blowers	1	lump sum	$70,000	$70,000
Granular activated carbon	1	lump sum	$60,000	$60,000
Piping	1	lump sum	$75,000	$75,000
Electric	1	lump sum	$100,000	$100,000
Building	1	lump sum	$200,000	$200,000
Misc. equipment	1	lump sum	$50,000	$50,000
Slurry Wall	1100	LF	$20	$22,000
Estimated Capital Cost				**$1,362,000**
<u>Contingency & Engineering Fees</u>				
Contingency (15%)				$204,300
Engineering Fees (20%)				$272,400
Total Estimated Capital Costs				**$1,839,000**
<u>Operation and Maintenance Costs</u>				
<u>Groundwater Extraction & Treatment</u>				
Extraction well pumps	1	lump sum	$10,000	$10,000
Treatment system	1	lump sum	$10,000	$10,000
Residuals disposal	24000	gallons	1	$24,000
System O&M labor	2080	hours	50	$104,000
Annual Cost				**$148,000**
Present Value - 15 yrs @ 5%	**10.38**			**$1,536,000**
<u>Discharge Monitoring Costs</u>				
Discharge Sampling	1	manday	600	$600
Equipment, materials & supplies	1	lump sum	100	$100
Sample analysis	1	sample	500	$500
Subtotal				$1,200
Present Value - 15 yrs @ 5%				**$12,000**

Tappan Terminal
Alternative G3 (Cont.)

Groundwater Monitoring Costs			
Groundwater sampling	2 mandays	600	$1,200
Purge water disposal	1 drum	200	$200
Equipment, material & supplies	1 lump sum	1000	$1,000
Sample analysis	8 samples	500	$4,000
Subtotal			$6,400
Present Value - 30 yrs @ 5%			**$277,000**
ars 1-10, 2X years 10-20, 1X years 20-30)			
Total Remedial Alternative Cost			**$3,664,000**

Alternative G4
Tappan Terminal site
Hydraulic Barrier, Groundwater Extraction and Treatment with Discharge to the Hudson River
Cost Estimate

Basis: Reagent injection for 2 years, followed by annual monitoring for 30 years

Item	Quantity	Units	Unit Cost	Total
Mobilization/Demobilization	1	lump sum	$50,000	$50,000
Chemical Oxidation System				
Pilot Test	1	lump sum	$100,000	$100,000
Injector system installation	1	lump sum	$555,000	$555,000
Chemical injection program	1	lump sum	$275,000	$275,000
Reagents	1	lump sum	$265,000	$265,000
Confirmation Sampling	1	lump sum	$35,000	$35,000
Subtotal				$1,280,000
Contingency & Engineering Fees				
Contingency (15%)				$192,000
Engineering Fees (15%)				$192,000
Total Estimated Capital Costs				**$1,664,000**
Groundwater Monitoring Costs				
Groundwater sampling	2	mandays	600	$1,200
Purge water disposal	1	drum	200	$200
Equipment, material & supplies	1	lump sum	1000	$1,000
Sample analysis	8	samples	500	$4,000
Subtotal				$6,400
Present Value - 30 yrs @ 5%				**$171,000**
Total Remedial Alternative Cost				**$1,835,000**

Proposed Remedy
Tappan Terminal site
Air Sparging / Soil Vapor Extraction, Excavation of Petroleum and Dye-Contaminated Soil, and Installation of a Soil Cover System
Cost Estimate

Basis: Air sparge / soil vapor extraction for 5 years. Excavation of 100 cubic yards of petroleum and dye-contaminated soil. Placement of geogrid over 10 acres of the site. Placement of a soil cover over the entire 15 acre site.

Item	Quantity	Units	Unit Cost	Total
Capital Costs				
Mobilization/Demobilization	1	lump sum	$300,000	$300,000
Site Preparation				
Clearing & Grubbing	8	Acres	$7,000	$56,000
Air Sparge & Soil Vapor Extraction				
Surface air barrier	6500	sq yds	$5	$32,500
Installation of AS wells and SVE laterals	1	lump sum	$235,000	$235,000
Installation of air sparging and vapor extraction & treatment system	1	lump sum	$275,000	$275,000
System building	1	lump sum	$20,000	$20,000
Pilot test	1	lump sum	$50,000	$50,000
Startup and testing	1	lump sum	$25,000	$25,000
Excavation of Contaminated Soil				
Excavation of Soil	100	cu yds	$10	$1,000
Transportation and Disposal	110	tons	$150	$16,500
Backfill	100	cu yds	$15	$1,500
Barrier and Soil Cover				
Bedding for Geogrid (6" soil)	8,200	cu yds	$15	$123,000
Geogrid	49,000	sq yds	$3	$147,000
12" general fill	24,300	cu yds	$15	$364,500
6" topsoil	12,200	cu yds	$25	$305,000
Seed, fertilize & mulch	73,000	sq yds	$1	$73,000
Storm Water Drainage System				
Diversion swale/berm	1,850	ft	$11	$20,350
Conveyance Piping	1,850	ft	$150	$277,500
Estimated Construction Cost				$2,322,850
Contingency & Engineering Fees				
Contingency (15%)				$348,428
Engineering Fees (15%)				$348,428
Environmental Easement				$1,000
Total Estimated Capital Cost				**$3,021,000**

Tappan Terminal
Proposed Remedy (Cont.)

Operation and Maintenance Costs

AS/SVE Operating and Maintenance Costs (includes service & power costs, sampling & monitoring and carbon replacement)	1		lump sum	225,000	$225,000
Present Value - 5 yrs @ 5%		**4.33**			**$974,000**

Long Term Site Management and Groundwater Monitoring

Site Inspection and Annual Certification	4	mandays	$600	$2,400
Vegetation Maintenance	1	Lump Sum	$5,000	$5,000
Miscellaneous Site Work	2	mandays	$600	$1,200
Groundwater Sampling	2	man days	$600	$1,200
Purge water disposal	1	drum	$200	$200
Equipment, materials & supplies	1	lump sum	$1,000	$1,000
Sample analysis	8	samples	$500	$4,000
Subtotal				$15,000
Present Value - 30 yrs @ 5%				**$231,000**
Total Operation, Maintenance and Site Management Costs				**$1,205,000**
Total Remedial Alternative Cost				**$4,226,000**