THE
WHITMAN
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FEASIBLITY STUDY REPORT

FOR

PERGAMENT MALL/CORNICHE DRY CLEANERS
STATEN ISLAND, NEW YORK
NYSDEC SITE CODE # 243012

VOLUME 1

SUBMITTED TO

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
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THE WHITMAN COMPANIES, INC.

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1.0 INTRODUCTION

This Feasibility Study (FS) for the Pergament Mall/Corniche Dry Cleaners (Pergament), Richmond Avenue, Staten Island, New York was prepared by The Whitman Companies, Inc. (Whitman) as part of an ongoing environmental investigation of this site.

This FS was prepared with reference to: 1) Part 300.430-Remedial Investigation/Feasibility Study and Selection of Remedy of 40 CFR-Environmental Protection Agency; 2) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA-Interim* Final, October 1988; and 3) 6NYCRR Part 375-1.10 - Remedy Selection. This FS is also based upon the procedures and results reported in the following documents:

- Atlantic Environmental Service, Inc. 1987. Environmental Site Assessment, Pergament Mall Staten Island

- Lawler, Matusky & Skelly Engineers. 1993. Phase II Investigation Pergament Mall Corniche Dry Cleaners

- Lawler, Matusky & Skelly Engineers. 1993. Hazardous Ranking System Prescore Site Inspection Narrative Report

- The Whitman Companies, Inc. January 1995. Remedial Investigation /Feasibility Report for Pergament Mall/Corniche Dry Cleaners

- The Whitman Companies, Inc. January 1996. Remedial Investigation/Feasibility Study Workplan for Pergament Mall/Corniche Dry Cleaners

- The Whitman Companies, Inc. February 1998. Progress Report for Pergament Mall/Corniche Dry Cleaners

- The Whitman Companies, Inc. August 1998. Remedial Investigation Report for Pergament Mall/Corniche Dry Cleaners

- The Whitman Companies, Inc. March 2000. Progress Report of Remedial Activities for Pergament Mall/Corniche Dry Cleaners

- The Whitman Companies, Inc. April 2000. Sampling Results and HRC® Information for Pergament Mall/Corniche Dry Cleaners

- The Whitman Companies, Inc. June 2000. Interim Remedial Measure for Pergament Mall/Corniche Dry Cleaners

- The Whitman Companies, Inc June 2000. Phase II Remedial Investigation Report for Pergament Mall/Corniche Dry Cleaners

This FS addresses the ground water contamination identified in monitoring wells MW-2, MW-3 and MW-4 at Pergament Mall, Staten Island, New York. This is the only environmental condition at this site that is suspected or known to have been caused by discharges at the Corniche Dry Cleaners.

1.1 Purpose

The primary objective of this FS report is to document the basis and procedures used in identifying, developing, screening and evaluating a range of remedial alternatives to address ground water contamination at the Pergament site. The primary objective is to provide NYSDEC with sufficient data to select a feasible and cost-effective remedial alternative(s) that protects public human health and the environment from the potential risks posed by the identified ground water contamination at the subject site.

1.2 Report Organization

This FS is comprised of eleven (11) sections as described below.

Section 1.0 presents the primary objective of the report and defines the criteria used in evaluation, as well as other factors important to the alternative evaluations.

Section 2.0 provides a summary of the site background information including a site description, and a presentation of the history and findings of the various site investigations.

Section 3.0 discusses the physical characteristics of the site, including the topography and regional/site geology, the hydrogeology, the potential ground water receptors, and the climatology and demography of the area surrounding the subject site.

Section 4.0 presents the nature and the extent of the identified contamination and Section 5.0 evaluates the impacts to potential receptors. Section 6.0 defines the remediation criteria and objectives. Section 7.0 begins the identification and initial screening of potential remedial technologies and process options.

Section 8.0 is a comparative analysis of the alternatives retained from the screening process used in Section 7.0. Finally, Section 9.0 presents a detailed analysis of the technologies based on an eight (8) point system of evaluation. Sections 10.0 and 11.0 present the conclusions and references, respectively.

1.3 Evaluation Criteria

This FS follows the basic methodology outlined in the National Contingency Plan (NCP) with consideration of the requirements in 6NYCRR Part 375 1.10, and includes an eight (8) point list of criteria for evaluating remedial alternatives.

1.4 Chemicals of Potential Concern

Based on the results of the historical sampling and the Phase II Remedial Investigation, an impact to the site ground water is observed in ground water monitoring wells identified as MW-2, MW-3 and MW-4. Specifically, Trichloroethylene (TCE) and Tetrachloroethene (PCE) were reported at concentrations above the New York State Department of Environmental Conservation (NYSDEC) Ground Water Standards (GWS).

2.0 SITE INFORMATION

2.1 Site Location

The Pergament Mall/Corniche Dry Cleaners (Pergament) site is located within the 18-acre shopping center complex of Pergament Mall on Staten Island in Richmond County, New York (Figure 1). The shopping center complex consists of a main core building and four (4) satellite buildings. The remainder of the property is paved and used primarily for parking. Corniche Dry Cleaners was located in the middle of the eastern satellite building (Figure 2). The space is currently leased to a Chinese restaurant. Surrounding properties are a mix of residential, commercial and retail sites, with the Fresh Kills Landfill located adjacent to and west of the Pergament Mall.

2.2 Site Description

Former operations of the Corniche Dry Cleaners have apparently impacted the shallow ground water table downgradient of the former leasehold. An investigation conducted by Atlantic Environmental Service, Inc., (Atlantic), of Colchester, Connecticut in 1987 identified a spill of PCE at the rear of the former dry cleaner's operation. It was reported that the contaminated soil was subsequently excavated, constituting a source removal action with regard to the impacted ground water. Investigations conducted by Lawler, Matusky & Skelly Engineers (LMS) and Whitman reported PCE and TCE in ground water monitoring wells immediately downgradient of the dry cleaners at concentrations exceeding the NYSDEC GWS.

The sampling procedures, sample locations, analytical parameters and laboratory results for all the investigation activities conducted by Atlantic, LMS and Whitman were previously presented in numerous reports submitted to the NYSDEC. These reports are referenced in Section 1.0 above and should be referred to for detailed information regarding sampling procedures and results of each site investigation.

2.3 History of Site Investigation

2.3.1 Investigation Conducted by Atlantic Environmental Service, Inc. (1987)

Atlantic conducted an Environmental Site Assessment of the entire Pergament Mall in August/September 1987. Corniche was a tenant in the Pergament Mall at this time.

During the Atlantic site assessment, it was reported that spills of PCE had occurred behind the Corniche shop. Corniche used PCE as a dry cleaning solvent. To assess the PCE spills, Atlantic conducted soil and ground water sampling. Contaminated soil located behind Corniche was excavated. Atlantic collected confirmatory samples following excavation to document the effectiveness of the cleanup effort. Atlantic prepared a letter dated September 30, 1988 evaluating remedial activities conducted at the Pergament Mall.

Atlantic advanced three (3) soil borings (BH-2A through BH-2C) in the area remediated behind Corniche. Samples were collected from each boring at a depth of 5 to 7 feet, (the assumed depth of the soil excavation) and were analyzed for volatile organic compounds (VOs). PCE was detected at low levels in all of the samples at concentrations ranging from 0.235 milligrams per kilogram (mg/kg) [BH-2B] to 2.06 ppm (BH-2A). TCE was detected in sample BH-2A (0.420 ppm) and Trans-1,2 Dichloroethene was identified in samples BH-2A and BH-2C (0.154 ppm and 0.172 ppm, respectively). The reported TCE and Trans-1,2 Dichloroethene concentrations were below the NYSDEC Soil Objectives to Protect Ground Water Quality (SOP). Only sample BH-2A had a PCE concentration slightly above the NYSDEC SOP of 1.4 mg/kg. Atlantic's post-excavation soil sampling demonstrated that their soil remediation by source removal was highly effective.

2.3.2 Investigation Conducted by Lawler, Matusky & Skelly Engineers (1992)

Following Atlantic's investigation, Lawler, Matusky & Skelly Engineers (LMS) of Pearl River, New York, under contract to NYSDEC, performed a Phase II Investigation at Pergament Mall. Phase II activities concentrated on investigating the impact of past discharges of PCE from Corniche. The following activities were conducted:

- Soil Gas Survey
- Subsurface Soil Sampling
- Installation and Sampling of Ground Water Monitoring Wells

A soil gas survey was conducted in May 1992. Fifty (50) soil gas points were installed, sampled. PCE and 1, 2-DCE were the predominant VOs detected. The highest soil gas concentrations were located behind and southwest of the building in which Corniche was located. Figure 3 presents the locations of the soil-gas points. By comparing Figure 3 with Figure 6, it can be seen that the areas of higher soil gas concentrations coincide with the areas where higher concentrations of PCE in ground water were measured.

In May 1992, LMS collected soil samples. Five (5) samples were collected and analyzed for VOs, Semivolatile Organics, EP Toxicity Metals, Polychlorinated Biphenols (PCBs), Pesticides and Total Metals. Concentrations of PCE, TCE and 1,2-DCE were below the laboratory method detection limits in all five (5) samples. All other compound concentrations were below the regulatory limits.

During the soil boring investigation, four (4) monitoring wells (MW-1 through MW-4) were installed and sampled in June 1992. The initial round of ground water samples were analyzed for VOs, Semivolatile Organics, Total Metals, PCBs, and Pesticides. Monitoring well locations are shown on Figure 6.

PCE, TCE, and 1,2-DCE were the predominant organic contaminants detected in the wells MW-2, MW-3, and MW-4. MW-1, the upgradient well, reported no detectable compound concentrations. PCE was the contaminant detected at the highest concentration. PCE results ranged from 210 micrograms per liter (µg/L) in MW-2 to 4,100 µg/L in MW-4. TCE concentrations ranged from 10 µg/L in MW-2 to 160 µg/L in MW-4. The highest 1,2-DCE concentration (320 µg/L) was reported in MW-4, while lowest result was reported in MW-2 at 10 µg/L. The NYSDEC

GWS is 5 μg/L for PCE, TCE, as well as 1-2-DCE. Ground water was determined to flow toward the southwest.

In December 1993, LMS prepared their *Hazardous Ranking System (HRS) Prescore Site Inspection Narrative Report* for submittal to the NYSDEC. This report evaluated potential receptors of the shallow ground water contamination at the Pergament site. **They identified no drinking water or surface water targets. Additionally, no soil or air exposure impacts were evaluated, as the site is paved. Finally, their report states that they did not identify or delineate a source of the ground water contamination. LMS obtained a HRS Prescore of 0.2. The ranking system score range can be from 0 to 100. The score obtained by LMS is considered very low.**

2.3.3 Investigations Conducted by The Whitman Companies, Inc. (1994)

The Whitman Companies, Inc. (Whitman) was contracted by Pergament Investment, Inc., the property owner of Pergament Mall, to further investigate their site. During this time period, Pergament Investment, Inc. entered into a *Remedial Investigation/Feasibility Consent Order* with the NYSDEC to complete a remedial investigation and prepare a feasibility study evaluating remedial alternatives to address the identified contamination. Whitman's investigation activities consisted of further site characterization and delineation of the contaminants.

2.3.3.1 Soil Investigation

In June and July of 1997, Whitman completed a soil boring and sampling program. The goal was to identify source soils contaminated with PCE and TCE. Sample locations were selected based upon the results of LMS's soil gas survey. Specifically, boreholes were advanced in the areas in which the highest PCE/TCE concentrations were reported by LMS. **With the exception of one (1) sample, W-3, all reported VO concentrations were below the SOP. Sample W-3 reported a PCE concentration of 2.1 mg/kg, slightly exceeding the NYSDEC soil criterion of 1.4 mg/kg.**

Whitman conducted a supplementary soil investigation in November 1999 and January 2000 at the direction of NYSDEC. Soil borings were installed to the east, south and west of the strip mall and beneath the flooring of the former dry cleaners. **All of the reported compound concentrations, including PCE and TCE, were below the SOP. Based on the investigations conducted by Whitman and others, no source area of soil contamination is present.** Table 1 presents a summation of the soil findings obtained by Whitman. Figure 4 presents the locations of the samples and summarizes the analytical results.

2.3.3.2 Surface Water Sampling

In April and June 1994, Whitman collected surface water samples from a tributary to Richmond Creek. This tributary was located approximately 1/4 mile north of Corniche (Figure 1). Samples were collected directly opposite a storm water outfall (designated as an upstream sample), at a downstream bend in the stream, and at a second outfall point, located further downstream and at a point downstream of the outfall. **All reported VO concentrations were below the NYSDEC Surface Water Quality Criteria.** Table 2 summarizes the results of the surface water sampling and Figure 5 presents the sample locations. Sometime after the samples were collected, the area of the outfalls was developed. A warehouse and parking lot are now situated in this area.

2.3.3.3 Air Monitoring Survey

As per the NYSDEC's comments, Whitman conducted a screening of the interior of the strip mall buildings to assess these areas for the presence of volatile organic compound vapors. The survey was conducted in January 2000. With the exception of Bella Vita and Gino's Pizza, the interiors of each of the buildings that comprise the eastern strip mall were monitored using a Photoionization Detector (PID). The two (2) establishments noted were not open and these leased areas could not be accessed for monitoring. The leasehold formerly occupied by Corniche was also monitored. **The survey reported that <u>no elevated PID readings</u> above background were present in any of the leaseholds evaluated.**

2.3.3.4 Ground Water Investigation

Whitman has collected up to six (6) additional rounds of ground water samples from MW-1, MW-2 and MW-3 during the time period of 1994 to 2000. MW-4 was paved over sometime after 1994 and could not be located by Whitman for sampling. A replacement to MW-4, (MW-4R) was installed in 1999 by Whitman and sampled. During Whitman's tenure, three (3) additional ground water monitoring wells were also installed as directed by NYSDEC and are identified as MW-5, MW-6 and MW-7. These three (3) wells were installed to monitoring ground water quality downgradient of MW-2, MW-3 and MW-4. Figure 6 presents the locations of the ground water monitoring wells.

Sample results from wells MW-2, MW-3 and MW-4 have consistently reported elevated PCE and TCE concentrations. However, the last round of sampling, (conducted in January 2000), reported lower PCE and TCE concentrations in MW-2. MW-3 reported PCE and TCE concentrations consistent with the previous rounds of sampling. Finally, the replacement well, MW-4R, reported PCE at a concentration greatly reduced from previous rounds, but still slightly exceeding the GWS. The TCE concentration in MW-4R reported was below the GWS. MW-1 (the upgradient well) and MW-5, MW-6 and MW-7 (the three downgradient wells) have always reported PCE and TCE concentrations either below the laboratory method detection limits or below the GWS.

Based on the data, the PCE/TCE plume is monitored by MW-2, MW-3 and MW-4R. Downgradient well sampling data indicate that the plume does not reach the sentinel wells (MW-5, MW-6 and MW-7) and has not migrated off site. The sampling data also indicate that the ground water contamination is decreasing (MW-2 and MW-4R). Table 3 summarizes the historical results for ground water sampling conducted by Whitman.

2.4 Summary of Investigations

To date, the soils, downgradient surface water, the strip mall's indoor air quality and the shallow ground water table have been evaluated during several environmental site investigations performed at the subject property.

The results of the soil sampling indicate that there are no source areas remaining (i.e. soil contamination) for the solvent contamination detected in the ground water. One (1) soil sample (W-3) reported PCE slightly exceeding the NYSDEC SOP. This area has been delineated by other sample locations and the PCE is limited to the vicinity of sample W-3. Due to the low concentrations of PCE at W-3, it is concluded that this area is not a source of the ground water contamination. No further action is proposed for soil.

The results of surface water sampling conducted at a drainage ditch reported concentrations of PCE and TCE below the NYSDEC Surface Water Quality criteria. The drainage ditch was the origin for a tributary to Richmond Creek. Recent field observations of the area reveal that there is now a strip mall in the area of this drainage ditch. The exposed portion of the drainage ditch closest to the Pergament Mall site is paved over. The water now flows through underground storm sewer piping and the tributary is now fed almost entirely through surface runoff. Due to the impermeable nature of the subsurface piping, it is unlikely that there is any direct interconnection between the overburden aquifer and the drainage ditch. Based on the above information and the fact that ground water contamination is not migrating off the Pergament site, no actions are proposed or required with regard to surface water.

Whitman conducted air monitoring of the interior areas of the strip mall. The survey results documented that no elevated volatile organic compound readings were present and thus there has been no adverse impact to the building interiors from the PCE release. These results are consistent with Whitman's findings with respect to the lack of source soil contamination. As a result of NYSDEC's letter of October 2000, additional interior air monitoring is being conducted in December 2000. However, all previous sampling results suggest that no Volatile Organic vapors will be detected in any of the interior leasehold spaces. Pergament will forward the results of that investigation to NYSDEC when available, and requests that consideration of the conclusions contained in this report not be delayed pending the completion of the air quality investigation.

Based on the latest round of ground water sampling data, PCE or TCE was either not detected or was found at decreased concentrations in six (6) of the seven (7) on site wells. MW-3 reported a slight increase of these two (2) compounds. However, the reported TCE and PCE concentrations in MW-3 were consistent with those reported in previous sampling rounds.

TCE and PCE concentrations reported in MW-4R have decreased drastically since the last round of sampling. Specifically, TCE decreased from 160 µg/L to 0.3 µg/L and is now in compliance with the NYSDEC's standard. Similarly, PCE has decreased from 4,100 µg/L to 18 µg/L in MW-4. The PCE concentration reported in MW-4R is nearly in compliance with the NYSDEC standard of 5 µg/L.

In MW-2, PCE and TCE concentrations, although not yet in compliance with NYSDEC's standards, have decreased from one-half (TCE) to two-thirds (PCE) the concentrations reported in previous round of sampling. Downgradient wells continue to report no detectable concentrations of either PCE or TCE.

As no active treatment technology has been applied, Whitman concludes that the decreasing compound concentrations in MW-2 and MW-4R are a function of one (1) or more of the following mechanisms: dilution; volatilization; biodegradation; absorption; and chemical reactions. Additionally, degradation and contaminant transport calculations (Attachment 1) indicate that both PCE and TCE compounds are degrading to below the NYSDEC standards well before reaching the property boundary.

Based on the results of the numerous investigations, no further action is necessary regarding soils, surface water or indoor air quality at the site. Ground water contaminant concentrations above NYSDEC criteria do remain in a few of the site ground water monitoring wells. The sections below evaluate potential remedial alternatives for the ground water contamination.

3.0 PHYSICAL CHARACTERISTICS OF STUDY AREA

3.1 Topography and Drainage

Surface elevations at the western end of the strip mall were measured at 32 feet above mean sea level (msl) (Figure 1). The site has an average surface gradient of 3 percent toward the southwest. A 15- foot high elevated area is located along the northeastern boundary.

Surface drainage is directed into below grade storm sewers that drain toward the southwest. Recharge to the shallow water aquifer from precipitation is limited to the unpaved/landscaped areas situated around the property. The majority of precipitation is collected as surface water runoff in the storm sewers.

3.2 Regional and Site Geology

Staten Island, the southernmost of the five (5) boroughs of New York City, lies at the junction of three (3) geophysical provinces: Triassic Lowland (Newark Basin), New England Upland, and the Atlantic Coastal Plain.

The complex geologic history of Staten Island is characterized by intermittent phases of active tectonism and sedimentation separated by long hiatuses of relative inactivity. The island has experienced two (2) or more orogenies, several inundations, and at least one (1) episode of glaciation. Consolidated and unconsolidated sediments from Cambrian to Holocene are present, and include schists, serpentinite, shales, sandstones, diabase, sands, silts, and clays.

The Pergament Mall property is underlain by glacial overburden, which is underlain by a serpentinite bedrock. Further descriptions are provided in the sections below. Figure 7 presents a bedrock contour map for the site and Figure 8 presents a cross-sectional view of the subsurface conditions at Pergament.

3.2.1 Bedrock

Pergament Mall (and most of the surrounding area) is underlain by a Proterozoic-Cambrian serpentinite bedrock. The serpentinite is a moderately weathered ovoid pluton formation and found to be dark green to mottled brown in color. This formation occupies approximately 34 square kilometers in the north-central portion of Staten Island and it is believed to be a downward extending, 1.3 kilometer-long, wedge-shaped formation. The Staten Island serpentinite is zoned, with the outer zone forming a highly sheared, talcose, magnetite-rich border and the interior zone comprising a partially altered, porphyritic olivine and enstatite rock (Behm). Prior to metamorphism, the original ultramafic igneous body consisted of Harzburgite-type peridotite, a very unstable mineral under atmospheric conditions (Roberts-Dolgin). These faults were classified by Miller in 1970, as cited by Roberts-Dolgin according to their orientation in relation to the rate of upward movement of the body during emplacement.

The presence of high-relief serpentinite in relation to the enclosing host rocks resulted from a northeast-southwest Triassic gravity fault. The serpentinite body is unconformably overlain by glacial ground moraine at the Pergament Mall site, and by Cretaceous sediments to the east and south, and finally by Triassic deposits to the west. It is uncertain whether the serpentinite is intrusive. Its structural relation with the schist is not clean, and therefore its age in the late Proterzoic to Cambrian span is also uncertain (Robert-Dolgin)

3.2.2 Overburden Materials

Upper Pleistocene deposits of Late Wisconsinian glacial drift overlie the bedrock unit at the Pergament Mall property. The drift consists of out-wash and terminal and ground moraine deposits. These deposits are mainly reddish-brown clay till derived chiefly from the Upper and Lower Triassic shales and sandstones. The thickness of this unconsolidated layer ranges from three (3) to 15 feet at the site. The ground moraine consists of poorly sorted material that has substantial amounts of clay. Local bodies of stratified sand and gravel commonly occur within the moraine.

3.3 Hydrogeology

3.3.1 Shallow (Upper) Zone

The shallow ground water occurs within the overburden unit with the water-saturated thickness consisting of only approximately 5 feet. The dominant hydraulic gradient is to the southwest, averaging 0.02 feet per feet (ft/ft). Ground water flow direction is to the southwest, generally following the surface topography, which nearly mirrors the bedrock surface. Figure 9 presents the most recent contour map, based on ground water elevations recorded in January 2000. The ground water flow direction reported for January 2000 is consistent with the previously established flow direction for the site, which is toward the southwest.

As previously reported to NYSDEC, results of slug testing conducted by LMS indicated that a typical hydraulic conductivity value for the saturated overburden in the vicinity of wells MW-2, MW-3 and MW-4 is 1.26×10^{-3} centimeter per second (cm/sec). This typical value (1.26×10^{-3} cm/sec) coupled with a 5-foot saturated thickness, indicates that a domestic well installed in the area would yield only an estimated 0.2 gallons per minute (gal/min). Results of slug testing performed by Whitman for wells MW-5 and MW-6 show that the average overburden hydraulic conductivity is much lower than conductivity in MW-2, 3, and 4. The geometric mean of the six (6) calculated conductivities is 2.77 x 10^{-4} cm/sec, reducing the estimated yield of the overburden aquifer to less than 0.2 gal/min.

Grain-size analysis and Atterberg limits tests were performed by LMS on samples retrieved from the screened zone of MW-1, MW-2, MW-3 and the original MW-4. The results indicated that the screened zone of the wells is surrounded by poorly sorted clayey to silty fine sand with gravel. Uniformity coefficients ranged from 91.2 to 478.6 and effective grain sizes ranged from 0.0042 millimeters (mm) to 0.012 mm. This data supports the field permeability tests and accepted parameters for glacial fill.

Samples collected by Whitman for the purposes of sieve analysis confirm that the overburden materials at the Pergament Mall site are poorly sorted clayey to silty sands, silts and very fine sands containing gravel.

3.3.2 Deeper (Lower) Zone

The deeper ground water system occurs within the serpentinite bedrock and is a poor aquifer. Very few wells tap this plutonic body, as the wells must be deep enough to intercept sufficiently transmissive fractures. One (1) well installed within the bedrock zone, yielded 3.5 gal/min (Soren, 1988). It has been estimated that a supply well installed in the serpentinite would need to extend to approximately 250 feet below the water table to obtain a sufficient yield of 10 gal/min (ibidem).

Development of ground water resources in bedrock in areas located downgradient of Pergament Mall (i.e. to the south and southwest) are precluded by the occurrence of a salt-water interface at a shallower interval than the depth required to obtain a sufficient freshwater yield. Available data reports that no ground water supply wells have been installed into the serpentinite downgradient of the Pergament Mall property (Soren, 1988).

The lower permeability of the serpentine bedrock, in relation to the slightly higher permeability of overburden materials, tends to promote lateral ground water flow within the overburden unit and vertical flow across the top of the bedrock. Furthermore, the vertical flow across the top of bedrock is likely to be directed upward. The occurrence of an upward flow from the bedrock is expected considering the elevation of the site and its location within a regional ground water discharge zone near the Richmond Creek. The fact that the water level elevation in MW-1 (completed within bedrock) is typically more than 10 feet higher than water levels in the other monitoring wells (complete in overburden) is consistent with the upward flow of ground water from the bedrock into the overburden unit. This upward flow creates a hydraulic barrier preventing the migration of dissolved contamination from the overburden unit into the bedrock.

3.3.3 Ground Water Recharge/Discharge

Precipitation on Staten Island is the main source of recharge to its ground water reservoirs. Annual recharge on Long Island, located to the east, is approximately 20 inches, yielding approximately one (1) million gallons per day per square mile (1 mgd/mi^2). Staten Island's land surface is hilly and less permeable than that of Long Island, with paved areas greatly reducing infiltration of water. Thus, the recharge conditions on Staten Island are estimated to range from approximately 0.25 to 0.5 mgd/mi^2. At these recharge rates, Staten Island's ground water reservoir would receive from 15 to 30 million gallons per day. As stated earlier, recharge local to the site is available in only the limited unpaved areas of the property and would occur through precipitation. However, the majority of precipitation and infiltration becomes surface water runoff that is collected into the site's stormwater drainage system.

Based on the New York-New Jersey U.S. Geological Survey (USGS) quadrangle topographic map for the Arthur Kill (Figure 1), an unnamed tributary of Richmond Creek was located southwest of the site and downgradient of wells MW-5, 6, and 7.

Field observations reveal that there is a strip mall in the area of this tributary's origin, which was observed to now be a drainage ditch. The exposed portion of the drainage ditch closest to the Pergament Mall site is now paved over. The majority of the stream flows through underground storm sewer piping and the tributary is now fed almost entirely through surface runoff. Due to the impermeable nature of the subsurface piping, there is likely no direct interconnection between the overburden aquifer and the tributary. Additionally, based on sampling data and ground water transport calculations, the contaminated ground water is not migrating off site.

3.4 Potential Ground Water Receptors

Information was obtained to identify the presence of any domestic, industrial, or water supply wells within a one-half mile radius of the site. There are reportedly no supply wells drilled into the either the shallow formation or serpentine bedrock anywhere downgradient of the site. State and local officials confirm that no ground water users are located in the vicinity (estimated 1/2 mile) of the Pergament Mall. These sources also confirm that all potable and industrial water needs on Staten Island are met via the New York City's public water supply. Furthermore, the public water supply on Staten Island does not utilize ground water resources. These officials confirm that there are no future plans to utilize ground water resources in the vicinity of Pergament Mall. LMS, based on information gathered during their investigations, concluded in their *Hazardous Ranking System Prescore Site Inspection Narrative Report* (LMS, 1993) that no drinking water supplies are expected to be impacted. **Based on the preceding information <u>there are no known receptors of ground water.</u>**

3.5 Climatology and Demography

Climatological and demographic data for the site and surrounding area of Staten Island was provided in Whitman's August 1998 report. However, a brief summary is given below. The climatological data was obtained from the National Oceanic and Atmospheric Association (NOAA) Climate Diagnostics Center web server and is presented for JFK Airport, the closest weather station to Pergament Mall.

Mean Annual Precipitation	41.8 inches
Mean Annual Snowfall	22.0 inches
Annual Average Chance of Precipitation	32.4%
Mean Maximum Temperature	82.8°F
Mean Minimum Temperature	25.2
Annual Average Wind Speed	11.2 mph

Demographic information within a 1/2 mile radius of Pergament Mall was provided by the Staten Island Economic Development Council. Census data from 1998 and for Census Block Groups 291.02, 277.02 and 279.02 were reviewed. Portions of each census block group lie within a 1/2 mile of the subject site.

Census Block Group	Population	Daytime Population
277.02	5,023	5,334
291.02	1,139	3,308
279.02	1,660	977

As previously discussed in above sections, none of the businesses or residences in the vicinity of the subject site uses local ground water resources. All water users rely on the public water supply system from New York City.

4.0 NATURE AND EXTENT OF CONTAMINATION

As a result of numerous investigations at the Pergament Mall property, ground water contamination, in the form of dissolved PCE and TCE, is present in three (3) ground water monitoring wells. Specifically, MW-2, MW-3 and MW-4 have in the past or at present, reported PCE and/or TCE concentrations above the NYSDEC GWS. Based on sampling data, the ground water contamination is not present in the upgradient well MW-1. Additionally, the three (3) downgradient wells, MW-5, MW-6 and MW-7 installed at NYSDEC's direction report no detectable concentrations of either PCE or TCE. The ground water contamination is fully delineated by the seven (7) wells and does not migrate off site.

No source contamination in the soils, surface water contamination and volatile organic air vapors from the former Corniche operations are present on this site. No further investigation or remedial actions will be conducted for these media.

5.0 EVALUATION OF IMPACTS ON POTENTIAL RECEPTORS

5.1.1 Exposure Pathways

Potential exposure pathways for the halogenated volatile organic compound contamination reported in the shallow water table at the Pergament site include the following:

- Vapor emissions
- Direct Physical Contact
- Ground Water
- Surface Water

5.1.2 Impact from Vapor Emissions

A soil gas survey was conducted by LMS in May 1992, in which 50 soil gas points were installed sampled and analyzed (Figure 3). LMS reported to NYSDEC that the data did not indicate a health risk due to the emissions of VO into the atmosphere. The highest soil gas reading was 740 milligrams per cubic meter (mg/m^3) for PCE. The NIOSH recommended exposure limit for this compound is 170 mg/m^3, based on a TWA for breathing concentrations during a 10-hour work day maintained for a 40-hour work week. The sample location for this result was located beneath the pavement and approximately 6 feet below grade.

Additionally, as discussed in Section 2.3.3.3, indoor air monitoring was conducted within the strip mall buildings. Readings above background were not recorded. Additional indoor monitoring is being conducted in December 2000 according to NYSDOH protocols. Results will be reported to NYSDEC in January 2001.

Based on the results of LMS' study, indoor air monitoring program conducted by Whitman and results of the remedial soil investigations, there is no reasonable potential for exposure to vapor emissions. All buildings within the zone of influence are constructed on concrete slab, with no basements or subsurface structures. Areas not covered by buildings are either paved or have concrete over them. **There is no potential impact from vapor emissions.**

5.1.3 Impact from Direct Contact

There is little to no potential for direct contact to contaminated soils or contaminated ground water at the site. An extensive soil sampling program was completed and no remaining source contamination was identified. Soils have been found to contain very low concentrations of chlorinated hydrocarbons well below the NYSDEC SCO. Only one (1) sample, W-3, reported a solvent concentration above the criteria. Specifically, this sample reported 2.1 mg/kg PCE, slightly exceeding the NYSDEC criterion of 1.4 mg/kg. This sample was collected from 11 to 12 feet in depth. The area of W-3 sample collection is paved.

The subject site has been fully developed, with buildings, pavement and other constructed structures covering the entire property. No intrusive construction activities are planned in the foreseeable future. Normal maintenance to the subsurface utilities is the only projected work that would require the excavation into soils. It is anticipated that such work would be completed from 0 to 5 feet below grade, well above the zone impacted in the area of sample W-3.

Depth to ground water in the impacted wells MW-2, MW-3 and MW-4 is approximately 8 feet below grade. As stated above, the only projected construction activities at the site are for the repair of utilities, with intrusion into the subsurface extending no more than 5 feet in depth.

5.1.4 Impact on Shallow Ground Water

Shallow ground water occurs within the overburden materials that overlie bedrock. The overburden ranges from 6 to 17 feet in thickness at the Pergament site. The saturated thickness of overburden is typically 5 feet thick.

Slug test results, previously completed by LMS, reported a hydraulic conductivity ranging from 1.11×10^{-4} cm/sec (MW-1) to 2.22×10^{-3} cm/sec (MW-3). Additional testing conducted by Whitman reported hydraulic conductivity of 1.18×10^{-5} cm/sec (MW-5) to 1.2×10^{-4} cm/sec (MW-6). The hydraulic conductivity for MW-7 has not been calculated. The geometric mean of the six (6) calculated conductivities is 2.77×10^{-4} cm/sec. As previously reported in Whitman's Remedial Investigation Report, (August 1998), based on the geometric mean hydraulic conductivity, the calculated average linear flow velocity for the site is 0.07 ft/day.

Whitman provided further analysis and calculations of the retardation and pollutant transport rates in the August 1998 report (see Section 5.0). As previously presented, the calculated pollutant transport rates for the two (2) compounds of concern are:

Compound	Pollutant Transport Rate
Tetrachloroethene	0.03 feet/day or 10 feet per year
Trichloroethene	0.04 feet/day or 15 feet per year

These pollutant transport rates indicate that downgradient transport of these dissolved organic compounds through the aquifer is relatively slow.

Further calculations were made in the August 1998 report that presented the time for the contaminant concentrations to naturally degrade to NYSDEC standards and the projected distance the compounds will migrate before reaching these standards. The calculations have been updated to include the most recent round of ground water data (January 2000). Attachment 1 summarizes the updated calculations. These calculations project that the PCE and TCE degrade before reaching MW-5, MW-6 or MW-7, which is consistent with actual site ground water quality. As detailed previously in this report, PCE and TCE concentrations in MW-5, MW-6 and MW-7 have always been below the laboratory method detection limits.

Calculations previously completed by Whitman, indicate that a domestic well installed in the overburden materials would yield an estimated 0.2 gal/min based on the low hydraulic conductivity coupled with the thin layer of saturated material. This pump rate is insufficient for domestic and public water supply use.

Based on data obtained and calculations completed by Whitman, productive use of the shallow ground water is infeasible. The shallow ground water is not used for potable or industrial purposes. Additionally, the slow transport rate of the compounds of concern indicate that off site impact does not occur before the compounds of concern degrade to concentrations below the NYSDEC GWS. Actual site ground water results confirm this conclusion. **No impact to the downgradient shallow water aquifer presently occurs and conditions at the site insure that no future impacts will occur.**

5.1.5 Potential for Deeper Ground Water Contamination

The deeper ground water system occurs within the serpentine bedrock. The Staten Island serpentine has been reported to be a poor aquifer (Soren 1988). A discussion of the characteristics of a deeper water aquifer (within the bedrock) was presented in Section 3.2.1

Available data show that no supply wells are known to be drilled into the serpentine bedrock anywhere downgradient of the site (Soren, 1988).

The area of possible future development of the ground water within the serpentine is located to the northeast, and significantly upgradient of the subject site, in the vicinity of Todt Hill. Any development of ground water from the serpentine in an area located downgradient of Pergament Mall is precluded by the occurrence of the fresh water, salt water interface at shallower depths. Available data report that no supply wells are drilled into serpentine downgradient of the site.

MW-1 is completed entirely in the bedrock and the other six (6) wells are screened above bedrock, in the overburden materials. Results of slug testing by LMS indicate that the bulk hydraulic conductivity for MW-1 is an order of magnitude lower than the reported hydraulic conductivity for the overburden wells. The significantly low permeability of the bedrock, compared to the overburden materials, promotes lateral ground water flow within the overburden unit with a secondary vertical flow across the top of bedrock.

The vertical flow across the top of bedrock is directed upward, because of the elevation of the site and its location within a regional ground water discharge zone near Richmond Creek. That the ground water elevation in MW-1 is typically more than 7 feet higher than water elevations reported in the other site wells is consistent with the upward flow of ground water from the bedrock into the overburden unit. This upward flow creates a hydraulic barrier preventing the migration of dissolved contamination into the bedrock and hence into deeper ground water.

There is virtually no potential that the on site contamination would have an adverse impact on human health or environment associated with the deeper ground water. This assessment is based upon the non-use of ground water from bedrock sources downgradient of the site (due to poor yield and potential salinity problems), as well as the occurrence of an upward hydraulic gradient across the top of bedrock at the Pergament site.

5.1.6 Impact on Surface Water - Tributary to Richmond Creek

Water samples were collected from the drainage ditch that is the origin of a tributary to Richmond Creek, at locations upstream of the ditch, opposite stormwater outfalls and at a downstream bend. Sampling results report that potential discharges from the subject site have had no impact on surface water quality. This is based upon:

- The results of all surface water samples were below the NYSDEC Water Quality Regulations

- Reported contaminant levels were the lowest at the downstream sampling point. This sample location is the closest to the Richmond Creek tributary and this is the most reflective of water quality for discharges to the creek.
- Downgradient wells MW-5, MW-6 and MW-7 report TCE and PCE below the laboratory method detection limits or below the NYSDEC GWS, indicating that the shallow ground water contamination has not migrated off site.

5.2 Public Health Evaluation

As discussed in the above sections, impact to the general public is nonexistent with the site conditions that are currently in-place at the Pergament Mall. There is no human exposure to the on site contaminated shallow ground water.

5.3 Basis for Conducting Feasibility Study

Soil investigations have determined that there is no remaining area of source contamination at the Pergament Mall site. Indoor air monitoring and surface water sampling have determined that the limited ground water contamination identified on site has not had any adverse impact on the site buildings or on the nearby surface water body.

Ground water investigations have determined that the wells identified as MW-2, MW-3 and MW-4 report chlorinated solvent concentrations above the NYSDEC GWS. However, downgradient wells, MW-5, MW-6 and MW-7 have reported no detectable concentrations of either PCE and TCE. These three (3) wells are located approximately 40 feet north and upgradient of the property boundary.

The FS is based upon the following criteria:

- The objective of the FS is aquifer restoration (not migration control) and no other media will be addressed;
- Only the contaminated shallow ground water will require remediation. Scientific data and reports from local officials demonstrate that the bedrock aquifer is not and will not be used as a potable water source; and
- There are no identifiable receptors (other than shallow ground water) that are impacted.

6.0 IDENTIFICATION OF REMEDIATION CRITERIA AND OBJECTIVES

6.1 Introduction

The purpose of this section is to identify the remediation criteria that will ultimately be applied to the Pergament Site. The objective of the remedial action is also defined.

6.2 Site Specific Applicable or Relevant Considerations

The primary concern during the development of remedial action objectives for a site is the degree of protection afforded by a given remedy to human health and the environment. Primary consideration is given to remedial alternatives that attain the NYSDEC GWS.

6.2.1 Definition of Remediation Criteria

In accordance with the NYSDEC memo entitled "Division of Technical and Administrative Guidance Memorandum: Determination of Soil Cleanup Objectives and Cleanup Levels," dated January 24, 1994 (HWR-94-4046), the recommended ground water cleanup objectives for the primary contaminants identified at the Pergament Mall property are listed below.

Contaminant	NYSDEC Ground Water Standard (μg/L)
Tetrachloroethene (PCE)	5
Trichloroethene (TCE)	5

Based on the evaluation of potential impact from vapors and soils on shallow and deep ground water, and to surface water, the above stated criteria are the only standards to be considered and applied to the site. The only impact from the dry cleaner discharge of PCE has been determined to be to the shallow ground water on site noting that the contamination is not migrating off site. Other vectors of potential impact are minimal to nonexistent based upon the location and nature of the contamination and the site conditions.

6.2.2 Remedial Action Objectives

One (1) Remedial Action Objective will be established for the cleanup activities at the Pergament Mall site:

- Restore ground water quality to MW-2, MW-3 and MW-4 to at or below the ground water quality criteria, as defined in Section 6.2.1.

7.0 IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

The purpose of this section is to present the development of remedial action objectives and to identify, screen and select the most appropriate technologies to address the ground water contamination in MW-2, MW-3 and MW-4 at the Pergament site. The selected technology(ies) will be required to meet the cleanup criteria that have been identified for the site (Section 6.2.1), as well as be protective of human health and the environment

The identification and screening of remedial technologies is completed in a stepped manner. A summary of the initial screening performed on potentially applicable ground water remediation technologies and process options for the Pergament site is presented in Table 4. The initial screening process was used to eliminate technologies that are not appropriate for implementation at the subject site. The screening process considered site-specific conditions, contaminant types and concentrations, and the area to be remediated. The "Screening Comments" in Table 4 indicate if a process option is removed from further consideration or retained for further evaluation during the FS. Process options are only removed at this time if they are technically infeasible or they cannot be effectively implemented.

Based on the initial screening the following alternatives have been retained for further consideration:

- No Further Action
- Interception Trenches (i.e. Subsurface Drains)
- Vertical Well Points (i.e. Extraction Wells)
- Pump and Treat Technologies
- Soil Vapor Extraction
- Air Sparging and Soil Vapor Extraction
- Dual Phase Extraction
- HRC® Application

8.0 EVALUATION AND SELECTION OF REPRESENTATIVE REMEDIAL ALTERNATIVES

In this section, technologies considered feasible after the initial screening process are described and evaluated. The evaluation process utilizes three (3) criteria: effectiveness, implementability, and relative cost.

8.1 No Further Action

Description: The No Further Action alternative is developed and evaluated to establish a baseline for comparison with other remedial alternatives.

Effectiveness: Based on the monitoring data, and use of site specific natural attenuation calculations (Attachment 1) it is concluded that the PCE and TCE concentrations will continue to decrease in MW-2 and MW-4. As the site is known to have natural components and/or processes (e.g. dilution, volatilization, biodegradation, absorption or chemical reactions) that are breaking down the contamination with time, the reported compound concentrations will decrease and/or degrade. If the contamination was to migrate, it would be detected in the downgradient monitoring points before it moved offsite, allowing for appropriate actions, as the shallow ground water moves only approximately 26 feet per year. MW-3 is approximately 200 feet upgradient of sentinel wells MW-5, MW-6 and MW-7. It is important to note that neither PCE or TCE have ever been detected in any of the three (3) sentinel wells.

Implementability: No Further Action is readily implemented.

Cost: The relative cost of this response action would be the lowest of the possible remedial alternatives.

Conclusion: Based on site data collected, the contamination is naturally attenuating through one (1) or more mechanisms and the contaminants do not migrate off site. The shallow ground water is not used for potable or industrial uses, as the pumping rates are not sufficient to obtain adequate volumes of water. Risks posed to human health and the environment are minimal. This alternative is therefore retained for further consideration.

8.2 Collection Technologies

These technologies involve the collection and management of ground water prior to subsequent treatment (Section 8.3.1) and/or disposal. Collection technologies are utilized to remove the contaminated ground water from the aquifer and to physically prevent or reduce plume migration. The selection of an appropriate ground water collection system depends upon the objectives of the remedial action, the depth of contamination, and most importantly the hydrogeologic characteristics of the aquifer.

8.2.1 Subsurface Drain System (Interception Trenches)

Description: This system uses horizontal trench drains or similar structures to collect and extract the ground water downgradient of the contamination plume. This system is most applicable for sites with low transmissivity and when the flow of the contaminated ground water must be controlled over a large area.

Effectiveness: This system does not directly reduce the volume or toxicity of the contaminants, but would serve to collect contaminated ground water for treatment. Although this method has been proven, the low hydraulic conductivity and low pollutant transport rates reported at the Pergament Mall site would require that the system be in operation for as long as it takes for the contaminants to reach the NYSDEC GWS. Very low recovery of ground water is also anticipated.

Field measurements and related hydraulic calculations demonstrate conclusively that the recharge of water into the shallow water bearing zone is insufficient to conduct a technically viable recovery of contaminated ground water.

Implementability: Installation of drains to the top of bedrock is technically feasible, but may require special measures to reach up to 17 feet in depth. This system also requires long term monitoring and operation. There are also constraints caused by the site buildings that preclude the installation of the drains in the best possible locations.

Cost: The cost to install barrier drains is low to moderate. However, long term operation, as would be the case at this site, would significantly increase the long-term cost of this alternative.

Conclusion: Subsurface drains will not be considered, as the collection rate of ground water would be too low to make this alternative feasible. Long term operation and maintenance costs are expected to be high.

8.2.2 Vertical Well Points

Description: Extraction wells consist of a series of vertical wells installed into the strata to remove the contaminated ground water. These systems are most useful in formations with high transmissivities and pumping rates.

Effectiveness: As with the subsurface drain system, the extraction wells do not directly reduce the volume or toxicity of the contamination, but are used prior to conducting treatment. Extraction well technology is well developed and highly reliable, when designed correctly.

Implementability: This system although simple, would require long term operation, due to the low pumping rate of the shallow water aquifer. Sufficient amounts of water would need to be withdrawn to be effective. Further, a large number of wells would be required to remove the required quantity of ground water.

Cost: The cost of extraction wells depends upon the number of wells, their depths and the rate of pumping. The relative costs for this technology is moderate.

Conclusion: This alternative will not be considered, as the hydrogeologic site conditions are not conducive to the collection and recovery of large amounts of water.

8.3 Treatment Technologies

Treatment technologies can be located on site using permanent treatment units. Although the same remedial technologies are applicable for on site or off site treatment of contaminated ground water, on site treatment is considered first to minimize transportation and handling costs. The available technologies for treating ground water are: physical, chemical and biological processes.

8.3.1 Physical Treatments

8.3.1.1 Pump and Treat

Physical treatments, such as "pump and treat" work through the separation of the contaminants from the water to be treated. The treated water may then be discharged or treated further by other methods. These systems are usually used in concert with collection technologies described in Section 8.2.

Description: All physical treatment methods considered utilize technologies to remove the contaminated water from the ground (i.e. collection technologies) and treatment at the surface prior to discharge or re-injection.

Effectiveness: This criteria is based upon recoverability of ground water and the design of the system. Treatment to obtain compound concentrations below certain levels can become technically challenging. Sufficient pumping rates are required to remove enough water for effective treatment. Such pumping rates are not feasible for the Pergament Mall site.

Implementability: The technology is readily available and could be implemented. However, performance is a function of contaminant solubility and subsurface geology. This technology is limited by low recovery rates of the shallow water aquifer at the Pergament site. An area to install and operate system(s) in the most suitable location is precluded by the site buildings and parking areas given this is a busy shopping center. Discharge and air permits will likely be required.

Field measurements and related hydraulic calculations demonstrate conclusively that the recharge of water into the shallow water bearing zone is insufficient to conduct a technically viable recovery of contaminated ground water.

Cost: The relative costs for this process is moderate to high.

Conclusion: Due to low pumping rates of the shallow water aquifer, low solubility of compounds of concern, and potential high costs, this technology is deemed as not feasible and therefore is not retained.

8.3.1.2 Soil Vapor Extraction

Description: This technology involves the treatment of the unsaturated zone by using vacuum pumps to withdraw air from the subsurface. This process is used as a treatment of the source soils.

Effectiveness: Performance is a function of contaminant volatility and vapor flow. Vapor flow is a function of soil permeability, water saturation and physical components of the site. Effectiveness decreases with substantially low soil permeability.

Implementability: Understanding the subsurface characteristics is key to the success of this treatment alternative. The site has limited areas for the installation and operation of this type of treatment system. A source of soil contamination is necessary for contaminant recovery. At the Pergament site, all known source soils were remediated.

Cost: This technology is relatively inexpensive when compared to others. Expenditures would be for the operation and maintenance of the system.

Conclusion: Although this technology is efficient for the remediation of TCE and PCE in soil and has an acceptable cost factor, the absence of source soils at the property eliminates the need for this technology. This technology will not be considered further.

8.3.1.3 Air Sparging and Soil Vapor Extraction

Description: Air is injected below the water table and then flows upwards through the contaminated ground water and contaminants are extracted. There is mass transfer of the contamination in the dissolved water phase to the sparged air. The sparged air is captured with a Soil-Vapor Extraction system.

Effectiveness: Sparging is limited to those compounds with an adequate Henry's Law constant. PCE and TCE have Henry's Law constants amenable to sparging. Injected air pathways are not always predictable and therefore use of system could allow the contamination to migrate.

Implementability: Due to site constraints, there is a limited area for installation and operation of an above ground treatment system. Pilot testing is required to determine the suitability of the site to this treatment option. Low permeability will likely preclude the use of this alternative.

Cost: Cost is high, as there needs to be pilot testing and system design phases. Costs are also high for the system components and continued operation and maintenance of the system.

Conclusion: Due to site constraints, low soil permeability, and lack of contaminated source soils, this technology is not applicable to the site. Costs of a pilot test and implementation an effective system is considered high. This alternative will not be considered further.

8.3.1.4 Dual Phase Extraction

Description: This technology involves the combined pumping of ground water and air. The technology takes advantage of the contaminant's volatility and solubility.

Effectiveness: This technology is suited for the contaminant types (i.e. PCE and TCE) that are present at the Pergament Mall site. Contamination both above and below the water table can be treated.

Implementability: Low hydraulic conductivity and soil permeability will preclude the use of this technology. Additionally, the site constraints prohibit the sitting of the fairly substantial aboveground areas required to house the treatment system. This technology involves ground water discharges, which would require permitting and monitoring.

Field measurements and related hydraulic calculations demonstrate conclusively that the recharge of water into the shallow water bearing zone is insufficient to conduct a technically viable recovery of contaminated ground water.

Cost: Costs are typically high, but vary based on the system design to adequately address the contamination.

Conclusion: Although potentially feasible, the low estimated rate of ground water recovery as well as logistical constraints for system installation eliminates this technology from further consideration.

8.3.2 Chemical Treatment

Chemical treatment processes generally involve the destruction of hazardous substances by reaction with other chemical species to alter them to non-hazardous gases, liquids or solids.

8.3.2.1 Hydrogen Release Compound (HRC®)

Description: The technology utilizes the introduction of a chemical to enhance the natural biological processes. HRC® is a material that when added to the subsurface that stimulates the rapid degradation of chlorinated solvent contaminants. HRC® is a food quality, polylactate ester that when applied slowly releases lactate. Lactate is metabolized by naturally occurring microorganisms, resulting in the creation of anaerobic aquifer conditions and the production of hydrogen. Microorganisms capable of reductive dechlorination use the hydrogen to remove chlorine atoms from the chlorinated hydrocarbons.

Effectiveness: Case studies report from an 80 to 96 percent reduction of chlorinated solvents. Success of system dependant upon proper design and installation.

Implementability: The technology is passive and completed insitu. Application is either through injection points of a grid system or through a barrier system. Installation of grid points and HRC® can be completed with minimal site disturbance.

Cost: Since active, engineered systems are not required to be designed, constructed, operated and maintained, costs for application of HRC® and subsequent monitoring are relatively low.

Conclusion: HRC® injection is a potentially feasible alternative. It is relatively low in cost when compared to other alternatives and is readily available. There would be minimal disruption or impact to the site. This technology is therefore retained for further evaluation and consideration.

8.4 Summary Of Retained Technologies And Process Options

The screening process eliminated collection methodologies, and treatment after the contaminated water is pumped to the surface. Table 5 summarizes the evaluation results and the technologies retained/not retained. Additionally, treatment of soils has been eliminated, as the investigation activities have no found a source of soil contamination. No further action (with monitoring) and a combination chemical/anaerobic bioremediation technology (i.e. HRC®) have been retained for further consideration.

9.0 DETAILED ANALYSIS OF RETAINED TECHNOLOGIES

In this section, potential remedial alternatives for the Pergament site are further evaluated. The alternatives have been screened for their effectiveness, implementability, and costs. In this section, the alternatives are further evaluated for the eight (8) criteria specified by the NYCRR Part 375-1.10. Unlike the federal regulations, the criterion of "State Acceptance" is not considered as the NYSDEC has the final decision to accept or reject the selected alternative(s). These criteria are:

- Conformity to the Criteria
- Overall Protectiveness of Public Health and the Environment
- Short-Term Effectiveness
- Long-Term Effectiveness
- Reduction of Toxicity, Mobility and Volume with Treatment
- Feasibility
- Cost
- Community Acceptance

The applicable remedial alternatives retained after the screening process are:

Alternative 1: No Further Action
Alternative 2: Application of HRC®

A detailed description and analysis of these alternatives, with respect the eight (8) criteria are presented in the following sections.

9.1 No Further Action

9.1.1 Description

This alternative involves no further action, allowing the compounds of concern to degrade through the natural processes that occur in the subsurface environment.

9.1.2 Conformity to the Criteria

This alternative relies on natural attenuation and other natural processes to achieve a reduction in the compound concentrations. Based on data recently obtained, a natural reduction process is occurring in MW-2 and MW-4. The concentration of TCE is below the NYSDEC standard in MW-4. Additionally, significant decreases were reported for TCE and PCE in MW-2, as well as for PCE in MW-4. Calculations based on accepted hydrogeologic equations using data obtained from the wells has determined that compliance with NYSDEC criteria will occur between one (1) and four (4) years for both of these wells. Other calculations report that the degradation will occur before the contamination reaches the downgradient wells. Analytical data from downgradient wells MW-5, MW-6 and MW-7 support these calculations. Attachment 1 contains the calculations and references with regard to contaminant degradation and migration.

The contamination in MW-3 has remained relatively unchanged in the last two (2) years. Based on calculations provided in Attachment 1, the ground water contamination should attenuate in approximately five (5) years. The calculations in Attachment 1 also show that the contamination will attenuate before it migrates off site.

9.1.3 Overall Protectiveness to Public Health and Environment

Impact of the contamination was evaluated in above sections. As previously discussed, impact from the ground water contamination is minimal to the public, as the area of impact is covered with pavement, and contact with the contaminated ground water is not an issue. Additionally, based upon the site conditions, off site shallow ground water, deep ground water, surface water and air quality in structures on site are not impacted by the site ground water contamination. Site measurements indicate that the hydraulic conductivity of the shallow water aquifer is such that movement of the contaminants is very slow. This is supported by the migration calculations presented in Attachment 1 in which the compounds will degrade to below NYSDEC standards before reaching the property line.

From at least 1987 to the end of their tenancy (circa 1996), Corniche operated a self-contained dry cleaning unit that vented no flue gas to the environment. Previous to 1987, it appears that Corniche operated a dry cleaning unit that was not self-contained, possibly the source of the PCE discharge. An area of PCE soil contamination was excavated in 1987. Corniche's operations ceased sometime after 1996. The PCE soil source was removed 13 years ago and PCE has not been used at the site for over four (4) years.

The dry cleaners operated an open system from the 1970's to sometime in the 1980's. By all best estimates, the release occurred prior to 1987, when the open dry cleaning system was in use and ground water was contaminated at the point of discharge. With a 13+ year old discharge, the plume has had adequate time to reach the sentinel wells MW-5, MW-6 and MW-7, but it has not. This is further support that natural processes are working to degrade the contaminants as they move through the aquifer and a no action natural attenuation alternative is viable.

9.1.4 Short Term Effectiveness

The No Further Action alternative involves the application of no remedial remedy. Based on migration and degradation calculations, the contaminants do not now migrate off site and will not do so in the future. Therefore, there are no short-term threats to neighboring downgradient properties. Evaluation of water sources for Staten Island reveal that shallow ground water is not currently used or proposed for use as a source of water, therefore, no threat exists to potable water sources.

9.1.5 Long Term Effectiveness

Based on the site conditions and calculations regarding the degradation of the contaminants, the compound concentrations will reduce over time in MW-2, MW-3 and MW-4. It is calculated that up to five (5) years will be required for the PCE and TCE concentrations to degrade to fully to comply with the NYSDEC criteria. Impact to other resources is not an issue, as the contamination will not move off site before degrading.

9.1.6 Reduction of Toxicity, Mobility and Volume with Treatment

Data and calculations presented in Attachment 1 indicate that the toxicity of the shallow ground water contamination will naturally degrade over time. These calculations also indicate that the contamination is not very mobile, as the flow rate for the aquifer is low. There is no change to the volume of contamination, expect through the natural degradation processes.

9.1.7 Feasibility

The No Further Action alternative is readily implemented and requires the additional of no other technologies.

9.1.8 Cost

Costs will be accrued to complete the necessary notifications and filings required for a No Further Action approach. The cost accrued from the evaluation of data and development for the No Action Alternative is approximately $10,000. It is estimated that the costs for this alternative would range from $5,000 to $8,000, depending on the degree of administrative notifications and reporting that may be required. Additional costs may be necessary to perform monitoring of the down gradient sentinel wells.

9.1.9 Community Acceptance

Community acceptance will be based on the results of public notice and cannot be accurately predicted at this time. However, given the fact that no receptors are impacted and that there is no risk of exposure to the general public, it is anticipated that this remedial alternative will be readily accepted by the community.

9.2 Application of HRC®

9.2.1 Description

This alternative uses the introduction of Hydrogen Release Compound (HRC®), a food quality polylactate ester that upon introduction to the subsurface, slowly releases lactate. Lactate is metabolized by naturally occurring microorganisms, resulting in the creation of anaerobic aquifer conditions and the production of hydrogen. Naturally occurring microorganisms capable of reductive dechlorination then use the hydrogen to remove chlorine atoms from the chlorinated hydrocarbons. Baseline sampling of various parameters are completed to determine the appropriate specifications for the chemical application. A pilot study would also be required to determine this alternative's potential for effectiveness.

9.2.2 Conformity to the Criteria

Reports by Regenesis, the manufacturer of HRC® indicate that significant reduction can be achieved in compound concentrations over time. No pilot testing has been performed to determine if HRC® will reduce the compound concentrations to the applicable GWS.

9.2.3 Overall Protectiveness of Public Health and the Environment

HRC® is a food grade product that is reported to not be harmful to human health or the environment. There would be no major short term risks to the community or site workers posed by this alternative. The application would be designed to reduce the compound concentrations to the appropriate levels. (i.e., NYSDEC GWS). Effectiveness would be based on aquifer conditions and appropriate design of the application.

9.2.4 Short-Term Effectiveness

This alternative involves the injection of chemicals to enhance and accelerate the natural degradation processes that occur in anaerobic subsurface conditions. Application activities are estimated to require up to one (1) week. Post application sampling would be conducted after the injection of the HRC®. The post application monitoring program would be based upon recommendations from Regenesis. No major short-term threats to the on site tenants or neighboring community are anticipated during these activities.

9.2.5 Long-Term Effectiveness

The major benefit associated with this alternative is that it would accelerate the natural attenuation process that is already occurring and that has been occurring at the site over the last 13 years. No waste materials would be generated or disposed. Effectiveness of this alternative may be documented through the collection and analysis of post application samples. However, Regenesis and others have reported rebounding of chemical concentrations after a period of time. Additional HRC® application may be required to address these occurrences.

9.2.6 Reduction of Toxicity, Mobility and Volume with Treatment

As reported by Regenesis, this technology has been proven to effectively reduce dissolved halogenated compound concentrations in ground water. The technology does not reduce the mobility of the contamination. The volume of contamination would be reduced via the chemical reactions that would change TCE and PCE to non-toxic chemicals. Preapplication and post application testing may be required to determine the amount of HRC® to be applied and to document the success of the chemical application. This technology has been proven on a limited number sites and has been used to effectively reduce high concentrations of halogenated compounds. However, its effectiveness to reduce lower concentrations, such, as those present at the Pergament Mall site, is not widely published. This technology may not fully reduce the compounds to the required levels at a rate that exceeds the rate of natural attenuation.

9.2.7 Feasibility

The subsurface conditions of an aquifer and the locations available for application can limit the effectiveness of the HRC®. In the case at hand, pilot testing has not been conducted to determine if the technology would be feasible in the field. The shallow water aquifer is comprised of a poorly sorted clayey to silty fine sand with gravel. The higher the clay content, the more difficult the application of the HRC®. Additionally, it is not clear that the injection would treat all of the necessary areas, as it is difficult to control the chemicals once they are injected into the subsurface. This technology may not be proven feasible once a pilot study is completed.

9.2.8 Cost

The estimated costs for a one (1) time injection of HRC® in the areas surrounding MW-2, MW-3, and MW-4 is $20,000. However, a pilot program is highly recommended to evaluate the feasibility of this technology. This is estimated at $8,000. The pilot and actual field application costs do not include baseline sampling, which is estimated at approximately $3,000. Post application monitoring would be required at approximately $3,000 per round. Total estimated costs are $35,000 to $50,000, plus any ground water monitoring specified NYSDEC.

9.2.9 Community Acceptance

Community acceptance will be based on the results of public notice and cannot be accurately predicted at this time. However, given the facts that no receptors are impacted and that there is no risk of exposure to the general public, it is anticipated that there would be no outstanding issues with the community for this remedial action.

10.0 CONCLUSIONS

Two (2) alternatives were considered following an initial technology screening process and a more comprehensive evaluation of possible treatment alternatives. The two (2) alternatives considered in the final evaluation step were:

Alternative 1: No Further Action
Alternative 2: Application of HRC®

Based on a detailed analysis, the subsurface conditions and costs favor Alternative 1 over Alternative 2. The effectiveness of the HRC® injection has not been documented for the Pergament site and the costs required to determine its effectiveness are well above those for

Alternative 1. It is concluded that there would be no added benefit of using HRC®, with one (1) exception. This exception is that the application may reduce the time required to bring the shallow ground water into compliance with the NYSDEC GWS. However, it has been estimated that given the natural site conditions, that the PCE and TCE concentrations will decrease within a five (5) year time frame. Additionally, there are no receptors and therefore a no further action/natural degradation alternative is feasible and still protective of the human health and the environment. Therefore, Alternative 1 is deemed the best choice to address the shallow water contamination at the Pergament Mall site.

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TABLE 1
PERGAMENT MALL
STATEN ISLAND, NEW YORK
SUMMARY OF SOIL SAMPLING DATA COLLECTED BY WHITMAN COMPANIES, INC.

Sample ID Lab Sample Number Sampling Date Sample Depth (feet) Units	Soil Cleanup Objectives to Protect GW Quality mg/kg	W-1 13176 07/23/97 7.0-8.0 mg/kg	W-2 13175 07/23/97 9.0-10.0 mg/kg	W-3 13174 07/23/97 11-12 mg/kg	W-4 13188 07/24/97 10.0-11.0 mg/kg	W-5 13187 07/24/97 10.0-11.0 mg/kg	W-6 13186 07/24/97 11.0-12.0 mg/kg	W-7 13185 07/24/97 10.0-12.0 mg/kg	W-8 13177 07/23/97 13.0-14.0 mg/kg	W-9 13182 07/24/97 10.0-12.0 mg/kg	W-10 13179 07/23/97 8.5-9.5 mg/kg
VOLATILE COMPOUNDS											
Chloromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	1.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	0.1	0.005	0.001	ND	0.0033	0.0026	0.0043	0.0017	0.001	0.0014	0.0011
Trichlorofluoromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.76	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	0.06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethyl Vinyl Ether	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	1.4	0.0045	ND	2.1	ND	0.0009	0.046	0.015	0.03	0.13	ND
1,1,2,2-Tetrachloroethane	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene (Total)	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Confident Conc.		0.0095	0.001	2.1	0.0033	0.0035	0.0503	0.0167	0.031	0.1314	0.0011
Total Estimated Conc. VOA TICs (s)		0	0	0	0	0	0	0	0	0	0

[shaded box] - Concentration Exceeds NYSDEC Soil Cleanup Objectives

NC - No Criteria for Individual Contaminant

ND - None Detected

NA - Not Analyzed

B - The analyte was found in the laboratory blank as well as the sample. This indicates possible laboratory contamination of the environmental sample.

J - The result is less than the specified detection limit but greater than zero. The concentration given is an approximate value.

* - W-16 is a Laboratory Blind duplicate of W-15

** - X-22 is a Laboratory Blind dupplicate of W-22

TABLE 1
PERGAMENT MALL
STATEN ISLAND, NEW YORK
SUMMARY OF SOIL SAMPLING DATA COLLECTED BY WHITMAN COMPANIES, INC.

Sample ID	Soil Cleanup Objectives to Protect GW Quality	W-11	W-12	W-13	W-14	W-15	W-16*	ISB-1	ISB-1	ISB-1	MW-4
Lab Sample Number		13189	13178	13180	13190	13183	13184	20272	20273	178182	170389
Sampling Date		07/24/97	07/23/97	07/23/97	07/24/97	07/24/97	07/24/97	09/05/97	09/05/97	01/07/00	11/19/99
Sample Depth (feet)		13.0-14.0	13.0-14.0	7.5-8.5	9.0-10.0	9.0-10.0	9.0-10.0	2.0-2.5	4.5-5.0	8-9	12-12.5
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
VOLATILE COMPOUNDS											
Chloromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	1.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	0.1	0.0053	0.0009	0.0012	0.0053	0.0012	0.0014	0.0027	0.0027	ND	0.0021J
Trichlorofluoromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.76	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	0.06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethyl Vinyl Ether	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	1.4	ND	ND	ND	ND	ND	ND	ND	ND	0.0039	ND
1,1,2,2-Tetrachloroethane	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.001J
Chlorobenzene	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene (Total)	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Confident Conc.		0.0053	0.0009	0.0012	0.0053	0.0012	0.0014	0.0027	0.0027	0.0039	0.0031J
Total Estimated Conc. VOA TICs (s)		0	0	0	0	0	0	0	0	0	0

[shaded box] - Concentration Exceeds NYSDEC Soil Cleanup Objectives

NC - No Criteria for Individual Contaminant

ND - None Detected

NA - Not Analyzed

B - The analyte was found in the laboratory blank as well as the sample. This indicates possible laboratory contamination of the environmental sample.

J - The result is less than the specified detection limit but greater than zero. The concentration given is an approximate value.

* - W-16 is a Laboratory Blind duplicate of W-15

** - X-22 is a Laboratory Blind dupplicate of W-22

TABLE 1
PERGAMENT MALL
STATEN ISLAND, NEW YORK
SUMMARY OF SOIL SAMPLING DATA COLLECTED BY WHITMAN COMPANIES, INC.

Sample ID Lab Sample Number Sampling Date Sample Depth (feet) Units	Soil Cleanup Objectives to Protect GW Quality mg/kg	W-17 170388 11/19/99 9-10 mg/kg	W-18 170386 11/19/99 1-2 mg/kg	W-18 170387 11/19/99 9-10 mg/kg	W-19 170385 11/19/99 12.5-13.5 mg/kg	W-20 170384 11/19/99 12-13 mg/kg	W-21 170383 11/19/99 11-12 mg/kg	W-22 170381 11/19/99 13-14 mg/kg	X-22** 170382 11/19/99 13-14 mg/kg
VOLATILE COMPOUNDS									
Chloromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	NC	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	1.2	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	1.9	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	0.1	0.0019J	0.0026J	0.0023J	0.0039J	0.0021J	0.0024J	0.0027J	0.0026J
Trichlorofluoromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	0.4	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	0.2	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	0.3	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	NC	ND	0.0042J	ND	ND	ND	ND	ND	ND
Chloroform	0.3	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.76	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.6	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	NC	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	0.3	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.7	0.0007J	0.0006J	0.0006J	ND	ND	ND	ND	ND
Dibromochloromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	NC	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	0.06	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	NC	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethyl Vinyl Ether	NC	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	NC	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	1.4	0.067	0.0007J	0.0008J	ND	0.025	0.0071	0.0008	ND
1,1,2,2-Tetrachloroethane	0.6	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	1.5	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	1.7	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5.5	ND	ND	ND	ND	ND	ND	ND	ND
Xylene (Total)	1.2	ND	ND	ND	ND	ND	ND	ND	ND
Total Confident Conc.		0.0696J	0.0081J	0.0037J	0.0039J	0.0271J	0.0095J	0.0035J	0.0026J
Total Estimated Conc. VOA TICs (s)		0.047	0	0.033	0	0	0.037	0.029	0.027

[shaded box] - Concentration Exceeds NYSDEC Soil Cleanup Objectives
NC - No Criteria for Individual Contaminant
ND - None Detected
NA - Not Analyzed
B - The analyte was found in the laboratory blank as well as the sample. This indicates possible laboratory contamination of the environmental sample.
J - The result is less than the specified detection limit but greater than zero. The concentration given is an approximate value.
* - W-16 is a Laboratory Blind duplicate of W-15
** - X-22 is a Laboratory Blind dupplicate of W-22

TABLE 2

Pergament Mall
Staten Island, New York
SURFACE WATER ANALYTICAL RESULTS: APRIL & JUNE 1994

SAMPLE LOCATION	ST-1		ST-2		ST-3		NYSDEC SURFACE WATER CRITERIA* (MG/L)
SAMPLE DATE	4/15/94	6/23/94	4/15/94	6/23/94	4/15/94	6/23/94	
VOLATILE ORGANICS (MG/L)							
BENZENE	ND	ND	ND	NS	ND	ND	0.0007
1,2-DICHLOROETHENE (TOTAL)	0.0027	0.0042	0.003	NS	ND	0.0042	0.050
TRANS-1,2-DICHLOROETHENE	NR	ND	NR	NS	NR	ND	0.050
CIS-1,2-DICHLOROETHENE	NR	0.0042	NR	NS	NR	0.0042	0.050
CHLOROFORM	0.0027	0.002	0.0027	NS	ND	0.001	0.007
METHYLENE CHLORIDE	ND	0.0024	ND	ND	ND	0.0017	0.050
TETRACHLOROETHENE	0.017	0.024	0.015	NS	ND	0.0093	0.050
TOULENE	0.014	0.0077	0.013	NS	0.0007 J	0.017	0.050
1,1,1-TRICHLOROETHANE	0.0016	0.004	ND	NS	ND	0.0047	0.050
TRICHLOROFLUOROMETHANE	ND	ND	ND	NS	ND	ND	0.050
XYLENES (TOTAL)	ND	ND	ND	NS	ND	ND	0.050
TOTAL CONCENTRATION TARGET COMPOUNDS	0.0353	0.0443	0.337	NS	0.0007 J	0.0379	0.100
CONCENTRATION LIBRARY SEARCH COMPOUNDS	0.01	0.017	ND	NS	0.007	0.019	NC

KEY

ND -NONE DETECTED
J -THE RESULT IS LESS THAN THE SPECIFIED DETECTION LIMIT BUT GREATER THAN ZERO (0). THE RESULT IS GIVEN AN APPROXIMATE VALUE.
B -SUBSTANCE DETECTED IN LABORATORY BLANK
NA -NOT ANALYZED
NR -NOT REPORTED BY LABORATORY
NC -NO CRITERIA
* -SURFACE WATER CRITERIA DERIVED FROM THE NYSDEC WATER QUALITY REGULATIONS TITLE 6, CHAPTER X, PARTS 702.15, 702.16 AND 703.5 (TABLE1) SOIL CLEANUP CRITERIA, REVISED 3/3/94

TABLE 3
PERGAMENT MALL
STATEN ISLAND, NEW YORK
HISTORIC GROUND WATER SAMPLING
RESULTS FOR VOLATILE ORGANIC COMPOUNDS

Sample ID Sampling Date Units	1994 NYSDEC Ground Water Standards / Criteria ug/l	MW-1 Jun-92 ug/l	MW-1 3/25/94 ug/l	MW-1 6/23/94 ug/l	MW-1 9/23/97 ug/l	MW-1 2/25/98 ug/l	MW-1 1/7/00 ug/l	MW-2 Jun-92 ug/l	MW-2 3/25/94 ug/l	MW-2 6/23/94 ug/l	MW-2 9/23/97 ug/l	MW-2 2/25/98 ug/l
Volatile Organic Compounds												
Acetone	50	ND	NS	-	-	-	-	19	-	-	-	-
Chloromethane	NC	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	NC	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	2	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	50	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	NC	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	5	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	5	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5	NR	NS	ND	ND	ND	ND	NR	NR	ND	ND	ND
cis-1,2-Dichloroethene	NC	NR	NS	ND	ND	ND	ND	NR	NR	5.8	90	92
Chloroform	7	ND	NS	ND	ND	ND	ND	ND	ND	1.4	ND	ND
1,2-Dichloroethane	5	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	5	ND	NS	ND	ND	ND	ND	ND	ND	**6.8**	ND	ND
Carbon Tetrachloride	5	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	NC	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	5	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	NC	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	5	ND	NS	ND	ND	ND	ND	**10 J**	ND	ND	**58**	**68**
Dibromochloromethane	50	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	NC	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	0.7	ND	NS	0.5	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	NC	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethyl Vinyl Ether	NC	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	NC	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5	ND	NS	ND	ND	ND	ND	**210**	**960**	**194**	**1000**	**1000**
1,1,2,2-Tetrachloroethane	5	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	5	ND	NS	0.8	ND	ND	ND	ND	**87**	ND	ND	ND
Chlorobenzene	5	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene (Total)	5	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Confident Conc. VOAs (s)		ND	NS	1.3	0	0	ND	220	1047	208	1148	1160
Total Estimated Conc. VOA TICs (s)		ND	NS	0.009	0	0	0	0	0	0	0	0

[ ] - Results above Ground Water Standards/Criteria
ND - None Detected
NC - No Criteria
NS - Not Sampled
NR - Not Reported by Laboratory
B - Substance detected in laboratory blank
J - The result is less than the specified detection limit but greater than zero. The result is an approximate value.
* - MW-9 is a laboratory blind duplicate of MW-6
* - MW-10 is a laboratory blind duplicate of MW-2

TABLE 3
PERGAMENT MALL
STATEN ISLAND, NEW YORK
HISTORIC GROUND WATER SAMPLING
RESULTS FOR VOLATILE ORGANIC COMPOUNDS

Sample ID Sampling Date Units	1994 NYSDEC Ground Water Standards / Criteria ug/l	MW-2 1/7/00 ug/l	MW-3 Jun-92 ug/l	MW-3 3/25/94 ug/l	MW-3 6/23/94 ug/l	MW-3 9/23/97 ug/l	MW-3 2/25/98 ug/l	MW-3 1/7/00 ug/l	MW-4 Jun-92 ug/l	MW-4 3/25/94 ug/l	MW-4 6/23/94 ug/l	MW-4 1/7/00 ug/l
Volatile Organic Compounds												
Acetone	50		ND	-	-	-	-		ND	-	-	-
Chloromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5	ND	NR	NR	ND	ND	ND	ND	NR	NR	ND	ND
cis-1,2-Dichloroethene	NC	40	NR	NR	78	14	ND	40	NR	NR	94	0.7
Chloroform	7	ND	ND	ND	ND	6.4	**8.1**	ND	ND	ND	ND	ND
1,2-Dichloroethane	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	5	ND	ND	**19 J**	**49**	ND	ND	ND	ND	**91**	**70**	ND
Carbon Tetrachloride	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	5	**32**	**52 J**	ND	ND	ND	**13**	**38**	**160 J**	ND	ND	0.3
Dibromochloromethane	50	ND	ND	ND	ND	18	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethyl Vinyl Ether	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5	**380**	**1800**	**2000**	**1500**	**1100**	**940**	**1200**	**4100**	**5600**	**4400**	**18**
1,1,2,2-Tetrachloroethane	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene (Total)	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Confident Conc. VOAs (s)		452	1852	2019	1627	1138.4	961.1	1278	4260	5691	4564	19
Total Estimated Conc. VOA TICs (s)		0	0	0.13 B	0	0	0	0	0	0.420 B	0	0

☐ - Results above Ground Water Standards/Criteria
ND - None Detected
NC - No Criteria
NS - Not Sampled
NR - Not Reported by Laboratory
B - Substance detected in laboratory blank
J - The result is less than the specified detection limit but greater than zero. The result is an approximate value.
* - MW-9 is a laboratory blind duplicate of MW-6
* - MW-10 is a laboratory blind duplicate of MW-2

THE WHITMAN COMPANIES, INC.

TABLE 3
PERGAMENT MALL
STATEN ISLAND, NEW YORK
HISTORIC GROUND WATER SAMPLING
RESULTS FOR VOLATILE ORGANIC COMPOUNDS

Sample ID Sampling Date Units	1994 NYSDEC Ground Water Standards / Criteria ug/l	MW-5 9/23/97 ug/l	MW-5 2/25/98 ug/l	MW-5 1/7/00 ug/l	MW-6 9/23/97 ug/l	MW-9* 9/23/97 ug/l	MW-6 2/25/98 ug/l	MW-6 1/7/00 ug/l	MW-7 03/21/00 ug/l
Volatile Organic Compounds									
Acetone	50	-	-	-	-	-	-		
Chloromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	NC	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	2	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	50	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	5	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	5	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	NC	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	7	0.6	ND	2.1	ND	ND	ND	ND	ND
1,2-Dichloroethane	5	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	5	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	5	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	NC	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	5	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	NC	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	5	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	50	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	NC	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	0.7	ND	ND	ND	0.5	ND	ND	ND	ND
trans-1,3-Dichloropropene	NC	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethyl Vinyl Ether	NC	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	NC	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5	0.3	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	5	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	5	ND	ND	ND	0.7	0.5	ND	ND	ND
Chlorobenzene	5	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5	ND	ND	ND	**9.8**	**5.7**	**5.7**	3.6	ND
Xylene (Total)	5	ND	ND	ND	**28**	**17**	**17**	**12**	ND
Total Confident Conc. VOAs (s)		0.9	0	2.1	39	23.2	22.7	15.6	ND
Total Estimated Conc. VOA TICs (s)		4	0	0	321	0	181	715	3.2

[ ] - Results above Ground Water Standards/Criteria
ND - None Detected
NC - No Criteria
NS - Not Sampled
NR - Not Reported by Laboratory
B - Substance detected in laboratory blank
J - The result is less than the specified detection limit but greater than zero. The result is an approximate value.
* - MW-9 is a laboratory blind duplicate of MW-6
* - MW-10 is a laboratory blind duplicate of MW-2

THE WHITMAN COMPANIES, INC.

TABLE 4
PRELIMNARY SCREENING OF REMEDIAL ALTERNATIVES
(Section 7.0)

Alternative	Technology	Description	Screening Comments
No Further Action	None	Self Explanatory	Required for Consideration (Section 8.1)
Containment:			
Slurry Walls	Installation of barrier walls	These subsurface barriers consist of vertically excavated trenches filled with slurry. The slurry, usually a mixture of bentonite and water, hydraulically shores the trench to prevent collapse and retards ground water flow	**Not Feasible,** Most of the approaches involve a large amount of heavy construction. Soil-bentonite backfills are not able to withstand attack by strong acids, bases, salt solutions, and some organic chemicals. There is the potential for the slurry walls to degrade or deteriorate over time.
Collection:			
Interception Trenches	Subsurface Drains	Perforated pipes installed in trenches backfilled with porous material to extract contaminated water	Potentially Feasible (Further evaluated in Section 8.2.1)
Vertical Well Points	Extraction	System of Wells to Extract Contaminated Water	Potentially Feasible (Further evaluated in Section 8.2.2)
Physical Treatments:			
Pump and Treat	On site Collection, Treatment and Discharge to site	Contaminated ground water removed from plume and treated.	Potentially Feasible (Further evaluated in Section 8.3.1)
Pump and Treat	On site collection and, treatment, disposal of treated water to off site facility	Contaminated ground water removed from plume and treated.	Potentially Feasible (Further evaluated in Section 8.3.1)
Pump and Treat	On site Collection with off site Treatment and Disposal	Off-site Treatment at Local POTW	Potentially Feasible(Further evaluated in Section 8.3.1)
Soil Vapor Extraction	Carbon Adsorption	Vacuum applied to extraction wells volatizes contaminants	Potentially Feasible (Further evaluated in Section 8.3.1.2)
Air Sparging/Soil Vapor Extraction	Collection/Extraction	Mobilizes contamination via introduction of air and extraction using soil vapor collection	Potentially Feasible (Further evaluated in Section 8.3.1.3)
Dual Phase Extraction	Removal of Air/Ground Water	Injection of air to mobilize the contaminants from ground water. Contaminated air is pumped and stripped of volatile organic compounds	Potentially Feasible (Further evaluated in Section 8.3.1.4)

TABLE 4
PRELIMNARY SCREENING OF REMEDIAL ALTERNATIVES
(Section 7.0)

Alternative	Technology	Description	Screening Comments
Hot Water or Steam Flushing/Stripping	Steam Injection/Contaminant Recovery	Steam is forced into an aquifer through injection wells to vaporize volatile and semivolatile contaminants. Vaporized components rise to the unsaturated zone where they are removed by vacuum extraction and then treated	**Not Feasible,** The target contaminant groups for hot water or steam flushing/stripping are SVOCs and fuels. VOCs also can be treated by this technology, but there are more cost-effective processes for sites contaminated with VOCs.
Chemical Treatments:			
HRC Application	Biological/Chemical Treatment	Introduction of chemicals to stimulate biological degradation of contaminants	Potentially Feasible (Further evaluated in Section 8.3.2.1)
Bioslurping	Combination of bioventing and vacuum-enhanced free-product recovery	Bioslurping is the adaptation and application of vacuum-enhanced dewatering technologies to remediate hydrocarbon-contaminated sites. Bioslurping utilizes elements of both, bioventing and free product recovery, to address two separate contaminant media	**Not Feasible,** No free product to be recovered and aerobic biodegradation of many chlorinated compounds may not be effective unless there is a co-metabolite present. Bioslurping is less effective in tight (low-permeability) soils
Chemical:			
Ion Exchange	Combination of a physical/chemical treatment	Ion exchange removes ions from the aqueous phase by exchange with counter ions on the exchange medium	**Not Feasible,** Alternative does not remediated halogenated volatile organic compounds
Precipitation/Coagulation	Removal of contaminants through precipitation	This process transforms dissolved contaminants into an insoluble solid, facilitating the contaminant's subsequent removal from the liquid phase by sedimentation or filtration. The process usually uses pH adjustment, addition of a chemical precipitant, and flocculation.	**Not Feasible,** Alternative does not remediate halogenated volatile organic compounds

TABLE 4
PRELIMNARY SCREENING OF REMEDIAL ALTERNATIVES
(Section 7.0)

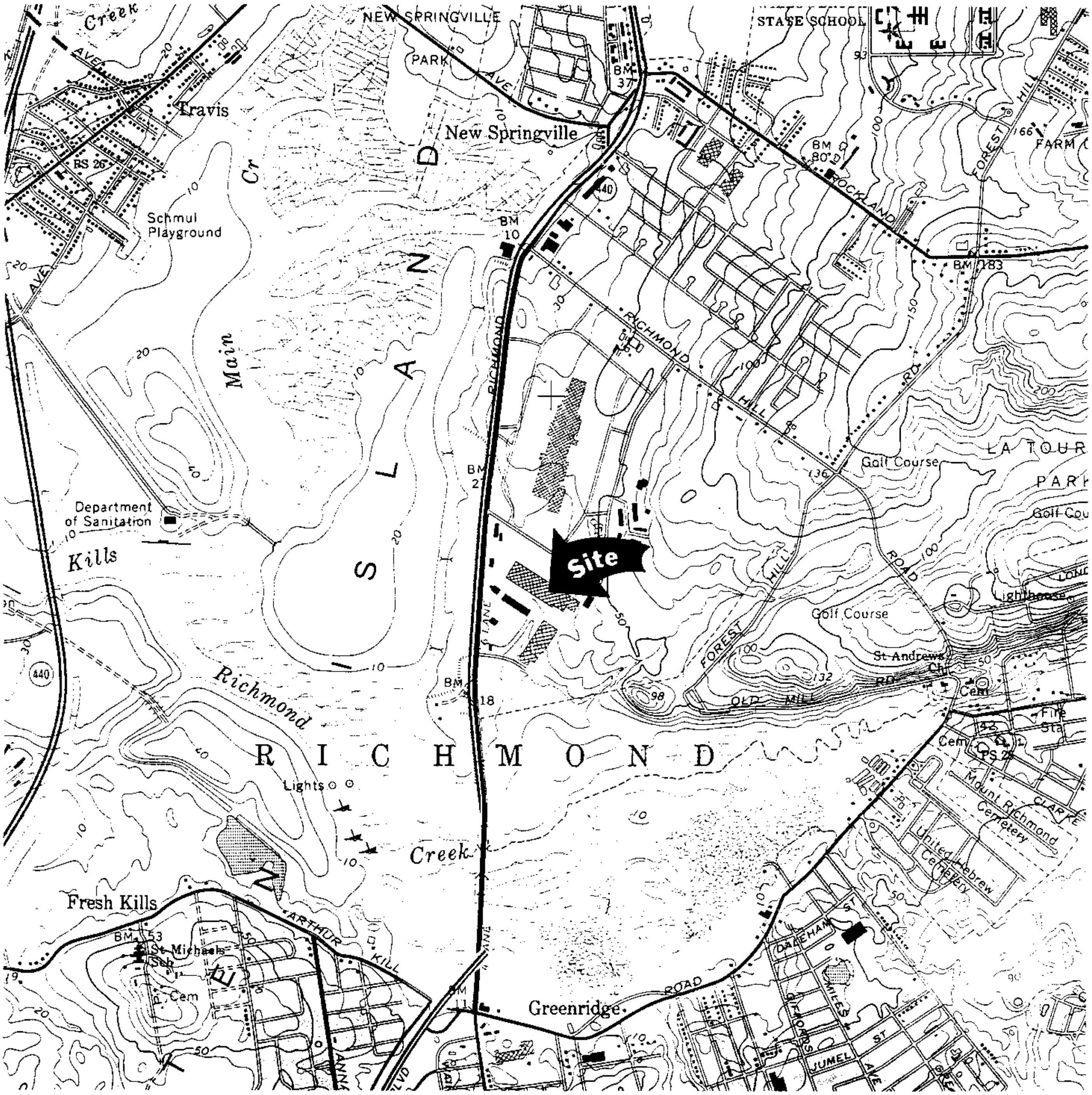
Alternative	Technology	Description	Screening Comments
Biological:			
Phytoremediation	Use of plants to degrade contaminants	Removal of contaminants by plants through phyto-degradation and phyto-volatization	**Not Feasible,** Works on shallow soils. Site constraints prohibit planting in areas to be treated. Large surface areas can be required for appropriate treatment
Co-Metabolic Treatment	Addition of methane or methanol supports methanotrophic activity, which has been demonstrated effective to degrade chlorinated solvents, such as vinyl chloride and TCE, by co-metabolism	An emerging application that involves the injection of a dilute solution of primary substrate (e.g., toluene, methane) into the contaminated ground water zone to support the co-metabolic breakdown of targeted organic contaminants	**Not Feasible,** This technology is still under development. Heterogeneous soils make it difficult to circulate the methane solution throughout every portion of the contaminated zone. Safety precautions (such as removing all ignition sources in the area) must be used when handling methane.

TABLE 5
SUMMARY OF RETAINED TECHNOLOGIES AFTER EVALUATION
(SECTION 8.0)

Alternative	Technology	Description	Screening Comments
No Further Action	None	Self Explanatory	**Retained for Detailed Analysis** (Section 9.1)
Collection:			
Inception Trenches	Subsurface Drains	Perforated pipes installed in trenches backfilled with porous material to extract contaminated water	**Not Retained** (Section 8.2.1) Collection rate of ground water would be too low. Long term operation and maintenance costs expected to be high since system must operate for a long time to be effective
Vertical Well Points	Extraction	System of Wells to Extract Contaminated Water	**Not Retained** (Section 8.2.2) Site conditions do not facilitate the collection and extraction of large quantities of water
Collection(for use with Physical Treatments):			
Pump and Treat	On site Collection, Treatment and Discharge to site	Contaminated ground water removed from plume and treated.	**Not Retained** (Section 8.3.1.1)
Pump and Treat	On site collection and, treatment, disposal of treated water to offsite facility	Contaminated ground water removed from plume and treated.	**Not Retained** (Section 8.3.1.1)
Pump and Treat	On site Collection with Offsite Treatment and Disposal	Off-site Treatment at Local POTW	**Not Retained** (Section 8.3.1.1) All three pump and treat scenarios are considered no feasible since the estimated low recovery rates of ground water.
Physical Treatments:			
Soil Vapor Extraction	Carbon Adsorption	Vacuum applied to extraction wells volatizes contaminants	**Not Retained** (Section 8.3.1.2) No source soils and low soil permeability remove this technology from consideration
Air Sparging/Soil Vapor Extraction	Collection/Extraction	Mobilizes contamination via introduction of air and extraction using soil vapor collection	**Not Retained** (Section 8.3.1.3) No source soils and low soil permeability remove this technology from consideration

TABLE 5
SUMMARY OF RETAINED TECHNOLOGIES AFTER EVALUATION
(SECTION 8.0)

Alternative	Technology	Description	Screening Comments
Dual Phase Extraction	Removal of Air/Ground Water	Injection of air to mobilize the contaminants from ground water. Contaminated air is pumped and stripped of volatile organic compounds	**Not Retained** (Section 8.3.1.4) Logistical constraints for installation and low potential rate of ground water recovery preclude use of this system..
Chemical:			
HRC Application	Biological/Chemical Treatment	Introduction of chemicals to stimulate biological degradation of contaminants	**Retained for Detailed Analysis** (Section 9.2)



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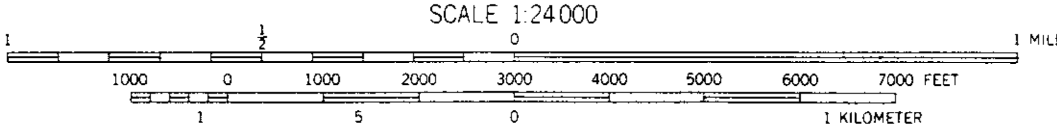
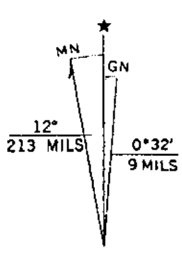
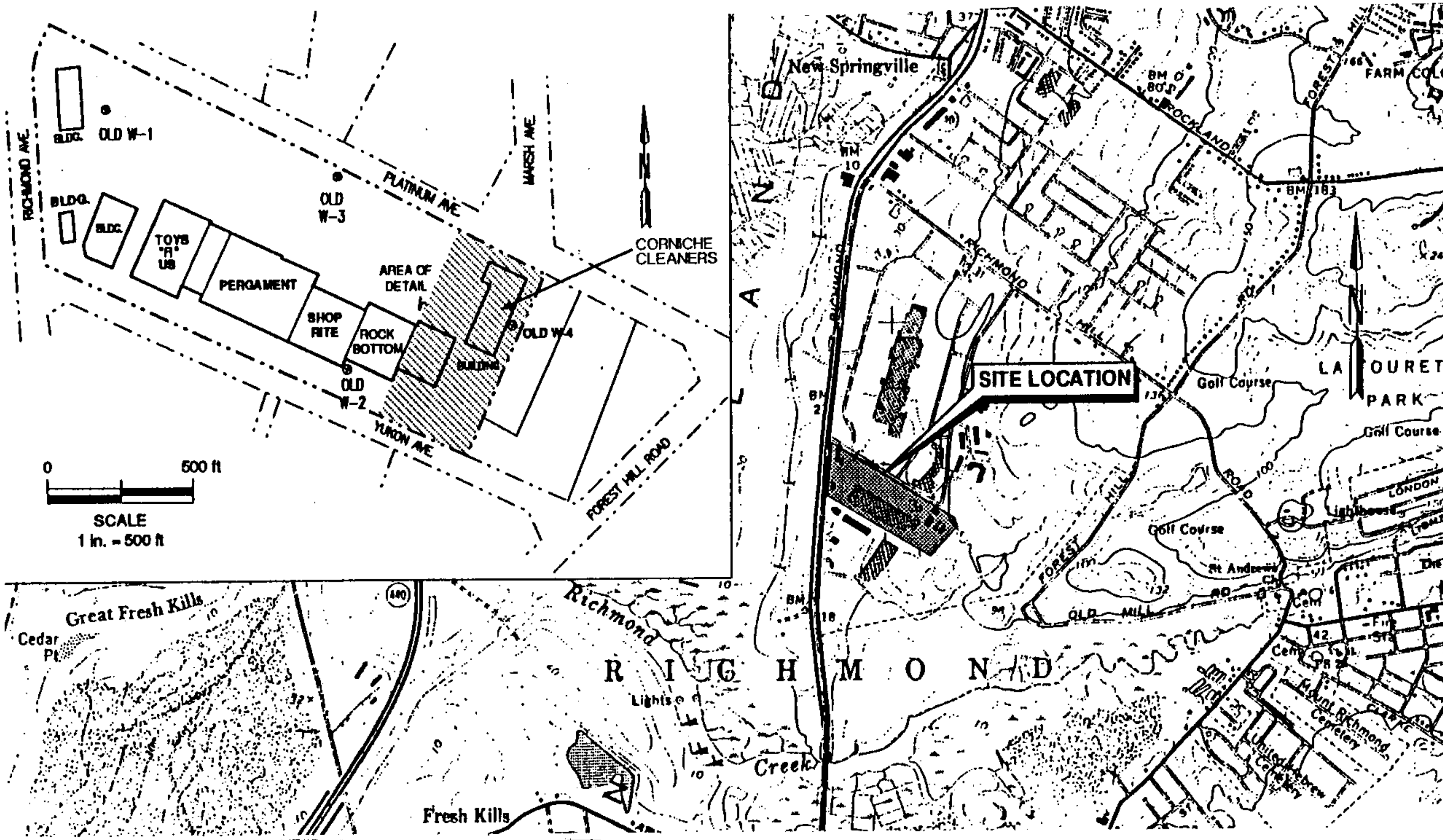




UTM GRID AND 1981 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION

THE WHITMAN CompanieS, INC.	PERGAMENT MALL STATEN ISLAND, NEW YORK	
	SITE LOCATION ON USGS ARTHUR KILL, NY QUADRANGLE	
	DATE: AUGUST 1994	FIGURE: 1
DWG.#:	DWG. BY: A. Villar	CHK. BY: BS



SITE COORDINATES:

LAT.: 40° 34' 31" x 40° 34' 36" N
LONG: 74° 09' 54" x 74° 10' 09" W

QUADRANGLE LOCATION

Map source: USGS quadrangle map, Arthur Kill, NY-NJ, 1966, photorevised 1981,

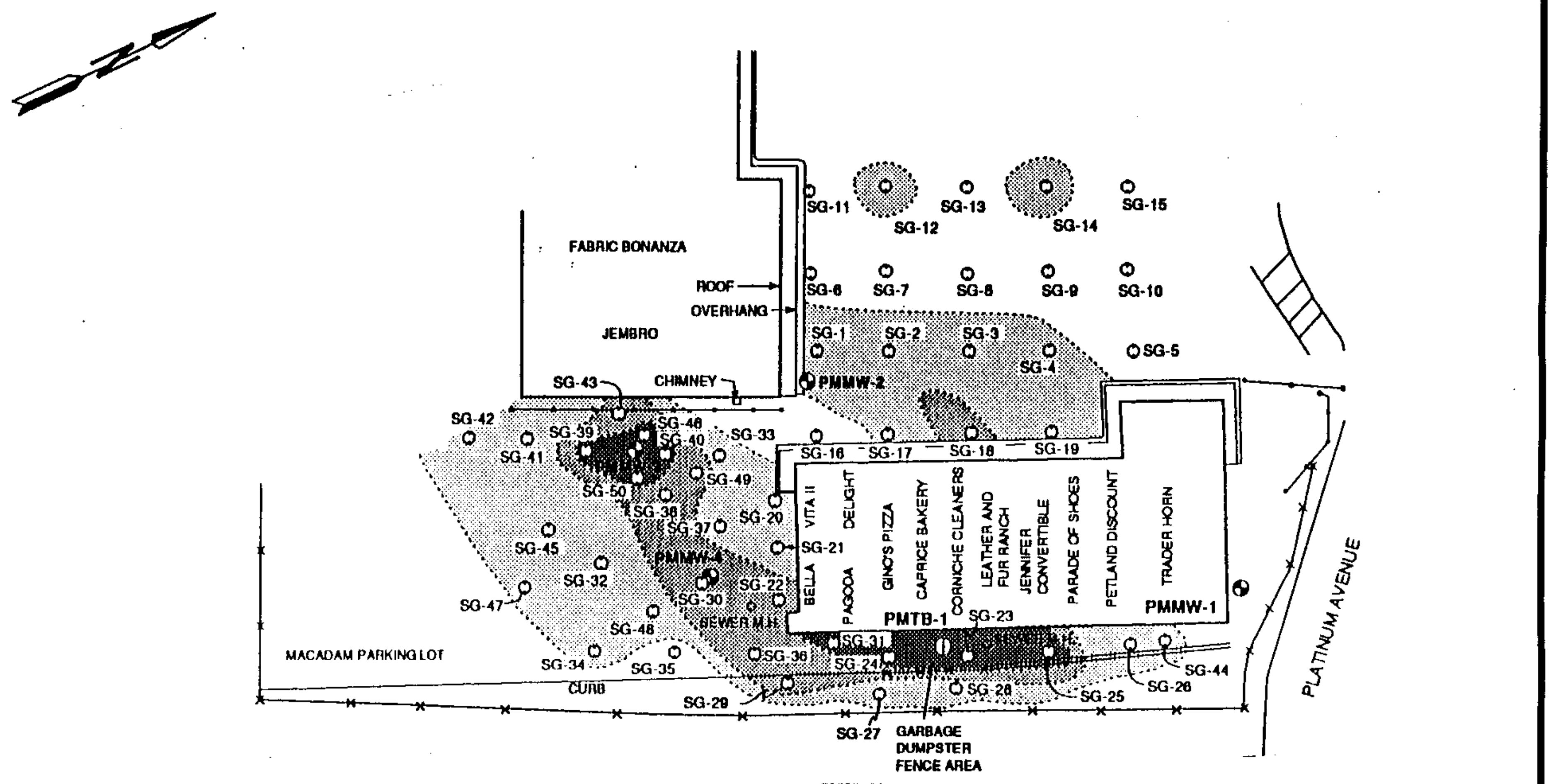
SOURCE: LMS ENGINEERS

THE WHITMAN CompanieS, INC.

PERGAMENT INVESTMENTS, INC.
STATEN ISLAND, NEW YORK

SCALED SITE PLAN

ORIGINAL BY: GW	DRAWN BY: A J	DRAWING NO:
CHECKED BY: GW	DATE: JULY 1998	FIGURE NO: 2



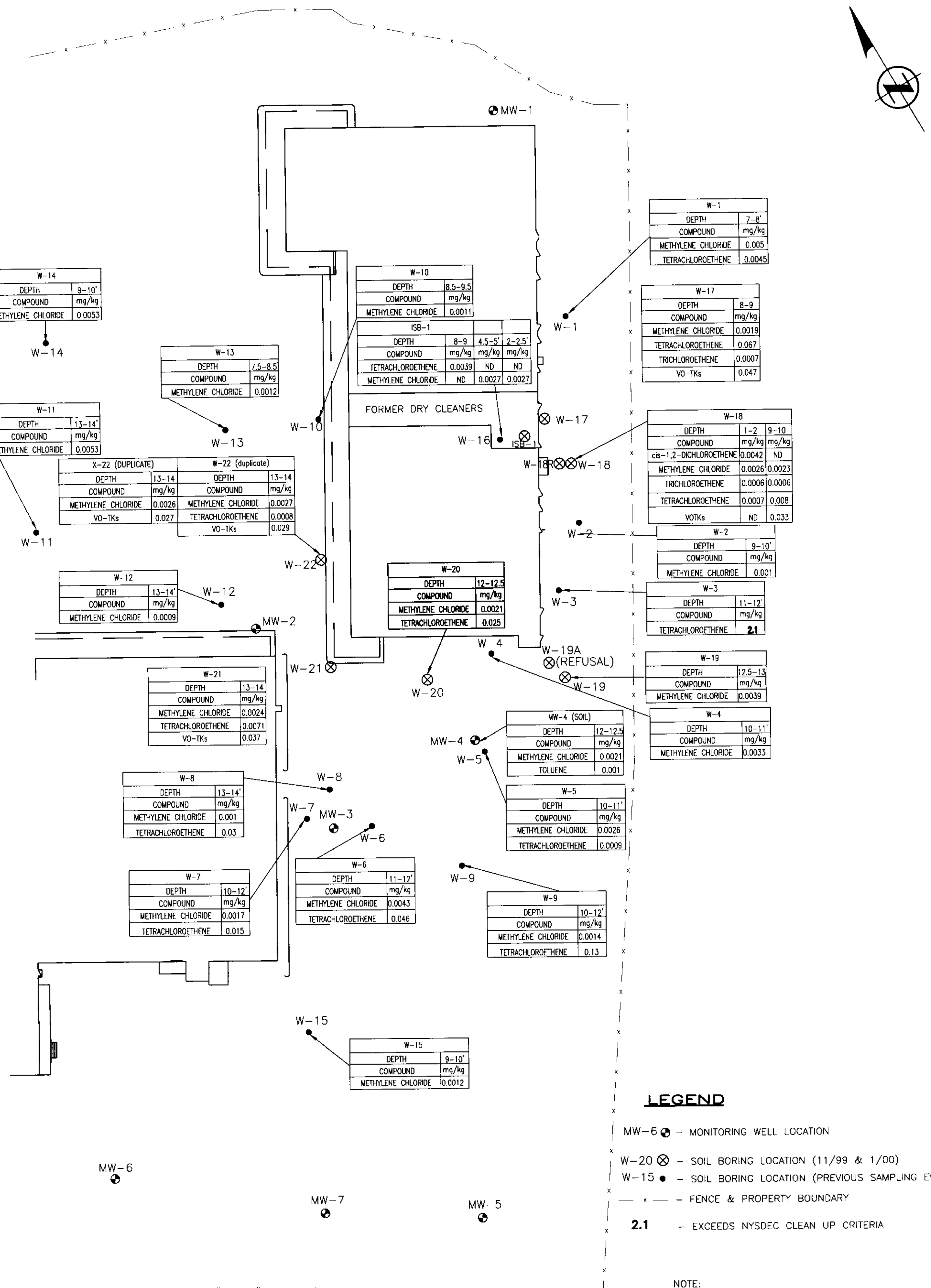
LEGEND

- Monitoring well location
- Test boring location
- Soil gas point location
- Areas of high chlorinated solvents concentration (>100,000 µg/m³)
- Areas of medium chlorinated solvents concentration (<100,000 µg/m³)
- Areas of low chlorinated solvents concentration (<10,000 µg/m³)

Map source: YEC survey, 12 June 1992.

SOURCE: LMS ENGINEERS

THE WHITMAN CompanieS, INC.	PERGAMENT INVESTMENTS, INC. STATEN ISLAND, NEW YORK	
	SOIL GAS RESULTS DELINEATION	
ORIG. BY: GW	DWG. BY: CJB	CHK. BY: GW
DWG.#:	DATE: JULY 2000	FIGURE: 3



W-14	
DEPTH	9-10'
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0053

W-10	
DEPTH	8.5-9.5
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0011

ISB-1			
DEPTH	8-9	4.5-5'	2-2.5'
COMPOUND	mg/kg	mg/kg	mg/kg
TETRACHLOROETHENE	0.0039	ND	ND
METHYLENE CHLORIDE	ND	0.0027	0.0027

W-1	
DEPTH	7-8'
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.005
TETRACHLOROETHENE	0.0045

W-17	
DEPTH	8-9
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0019
TETRACHLOROETHENE	0.067
TRICHLOROETHENE	0.0007
VO-TKs	0.047

W-13	
DEPTH	7.5-8.5'
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0012

W-11	
DEPTH	13-14'
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0053

X-22 (DUPLICATE)	
DEPTH	13-14
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0026
VO-TKs	0.027

W-22 (duplicate)	
DEPTH	13-14
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0027
TETRACHLOROETHENE	0.0008
VO-TKs	0.029

W-18		
DEPTH	1-2	9-10
COMPOUND	mg/kg	mg/kg
cis-1,2-DICHLOROETHENE	0.0042	ND
METHYLENE CHLORIDE	0.0026	0.0023
TRICHLOROETHENE	0.0006	0.0006
TETRACHLOROETHENE	0.0007	0.008
VOTKs	ND	0.033

W-2	
DEPTH	9-10'
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.001

W-12	
DEPTH	13-14'
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0009

W-20	
DEPTH	12-12.5
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0021
TETRACHLOROETHENE	0.025

W-3	
DEPTH	11-12'
COMPOUND	mg/kg
TETRACHLOROETHENE	**2.1**

W-21	
DEPTH	13-14
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0024
TETRACHLOROETHENE	0.0071
VO-TKs	0.037

W-19	
DEPTH	12.5-13
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0039

MW-4 (SOIL)	
DEPTH	12-12.5
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0021
TOLUENE	0.001

W-4	
DEPTH	10-11'
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0033

W-8	
DEPTH	13-14'
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.001
TETRACHLOROETHENE	0.03

W-5	
DEPTH	10-11'
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0026
TETRACHLOROETHENE	0.0009

W-6	
DEPTH	11-12'
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0043
TETRACHLOROETHENE	0.046

W-7	
DEPTH	10-12'
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0017
TETRACHLOROETHENE	0.015

W-9	
DEPTH	10-12'
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0014
TETRACHLOROETHENE	0.13

W-15	
DEPTH	9-10'
COMPOUND	mg/kg
METHYLENE CHLORIDE	0.0012

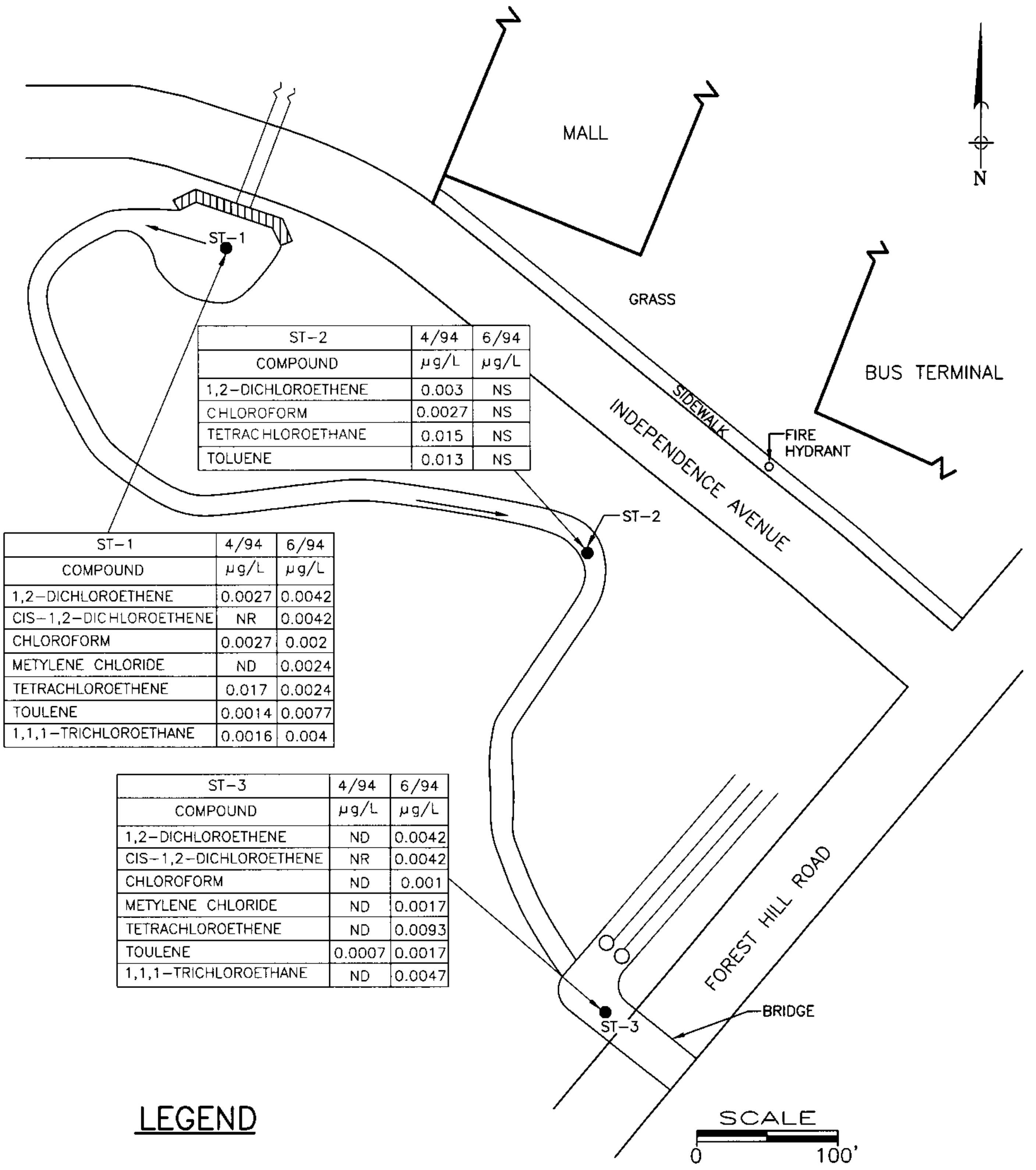
LEGEND

- MW-6 – MONITORING WELL LOCATION
- W-20 – SOIL BORING LOCATION (11/99 & 1/00)
- W-15 – SOIL BORING LOCATION (PREVIOUS SAMPLING EVENTS)
- — x — – FENCE & PROPERTY BOUNDARY
- **2.1** – EXCEEDS NYSDEC CLEAN UP CRITERIA

NOTE:
DATUM ESTABLISHED FROM AN ASSUMED BENCHMARK PREVIOUSLY ESTABLISHED BY L.M.S.

SCALE
0 50'

THE WHITMAN CompanieS, INC.	PERGAMENT INVESTMENTS, INC. STATEN ISLAND, NEW YORK	
	WHITMAN SOIL BORING LOCATIONS AND ANALYTICAL RESULTS	
ORIG. BY: GW	DWG. BY: TAG	CHK. BY: GW
DWG.#: 940103C3	DATE: JAN. 2000	FIGURE: 4



ST-2	4/94	6/94
COMPOUND	μg/L	μg/L
1,2-DICHLOROETHENE	0.003	NS
CHLOROFORM	0.0027	NS
TETRACHLOROETHANE	0.015	NS
TOLUENE	0.013	NS

ST-1	4/94	6/94
COMPOUND	μg/L	μg/L
1,2-DICHLOROETHENE	0.0027	0.0042
CIS-1,2-DICHLOROETHENE	NR	0.0042
CHLOROFORM	0.0027	0.002
METYLENE CHLORIDE	ND	0.0024
TETRACHLOROETHENE	0.017	0.0024
TOULENE	0.0014	0.0077
1,1,1-TRICHLOROETHANE	0.0016	0.004

ST-3	4/94	6/94
COMPOUND	μg/L	μg/L
1,2-DICHLOROETHENE	ND	0.0042
CIS-1,2-DICHLOROETHENE	NR	0.0042
CHLOROFORM	ND	0.001
METYLENE CHLORIDE	ND	0.0017
TETRACHLOROETHENE	ND	0.0093
TOULENE	0.0007	0.0017
1,1,1-TRICHLOROETHANE	ND	0.0047

LEGEND

ND – NOT DETECTED

NR – NOT REPORTED BY LABORATORY

NS – NOT SAMPLED

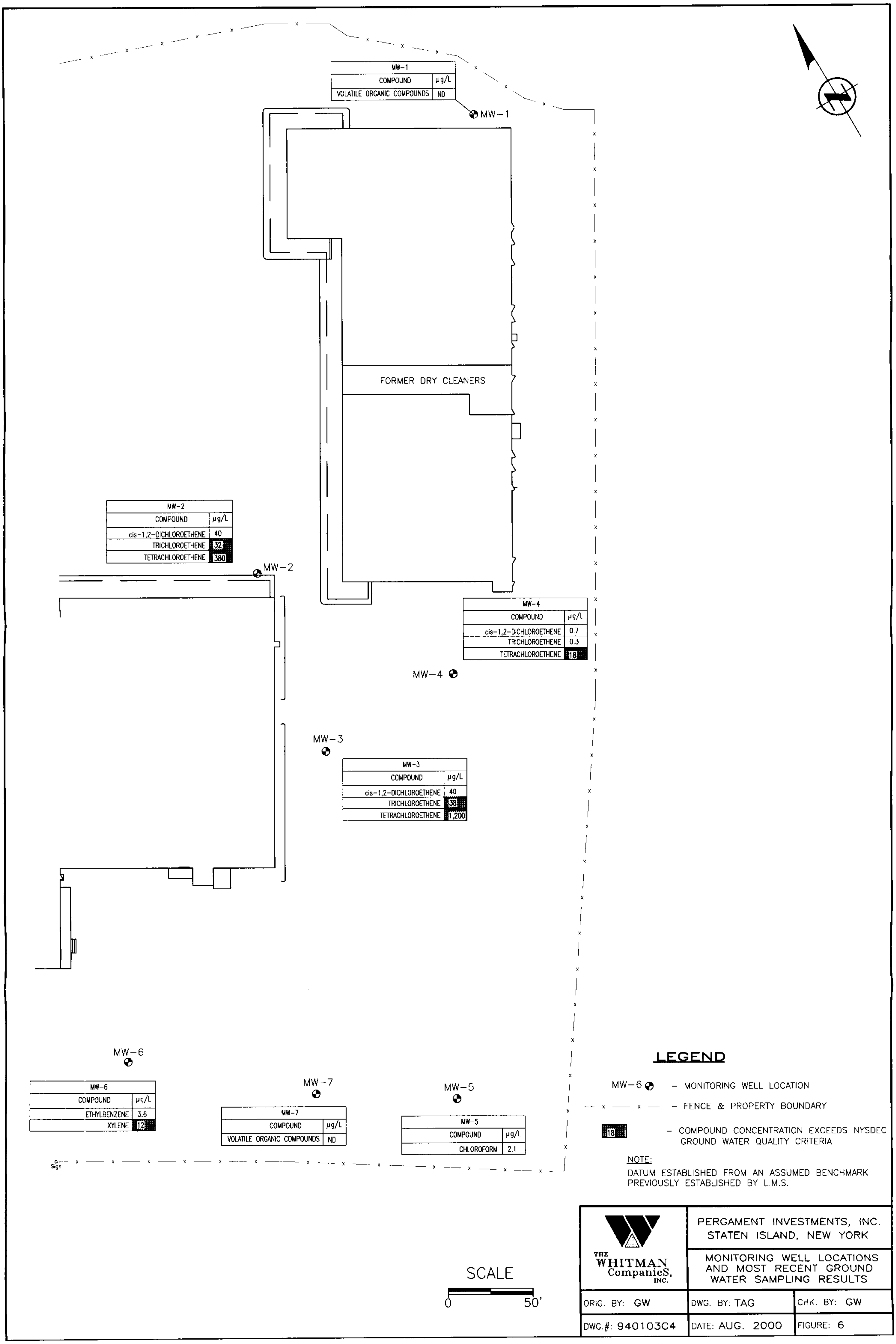
* ALL RESULTS REPORTED IN mg/l

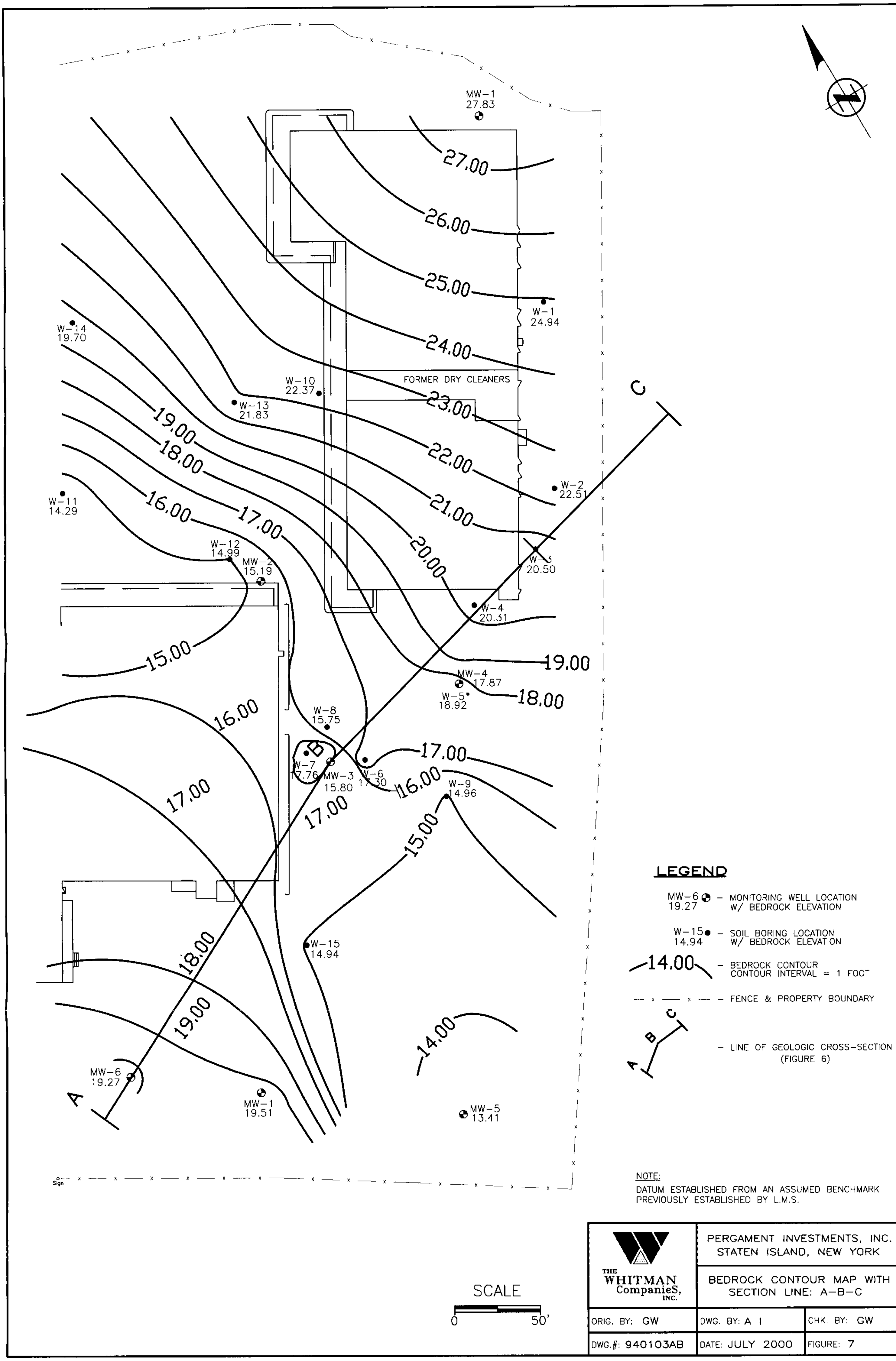
THE WHITMAN CompanieS, INC.

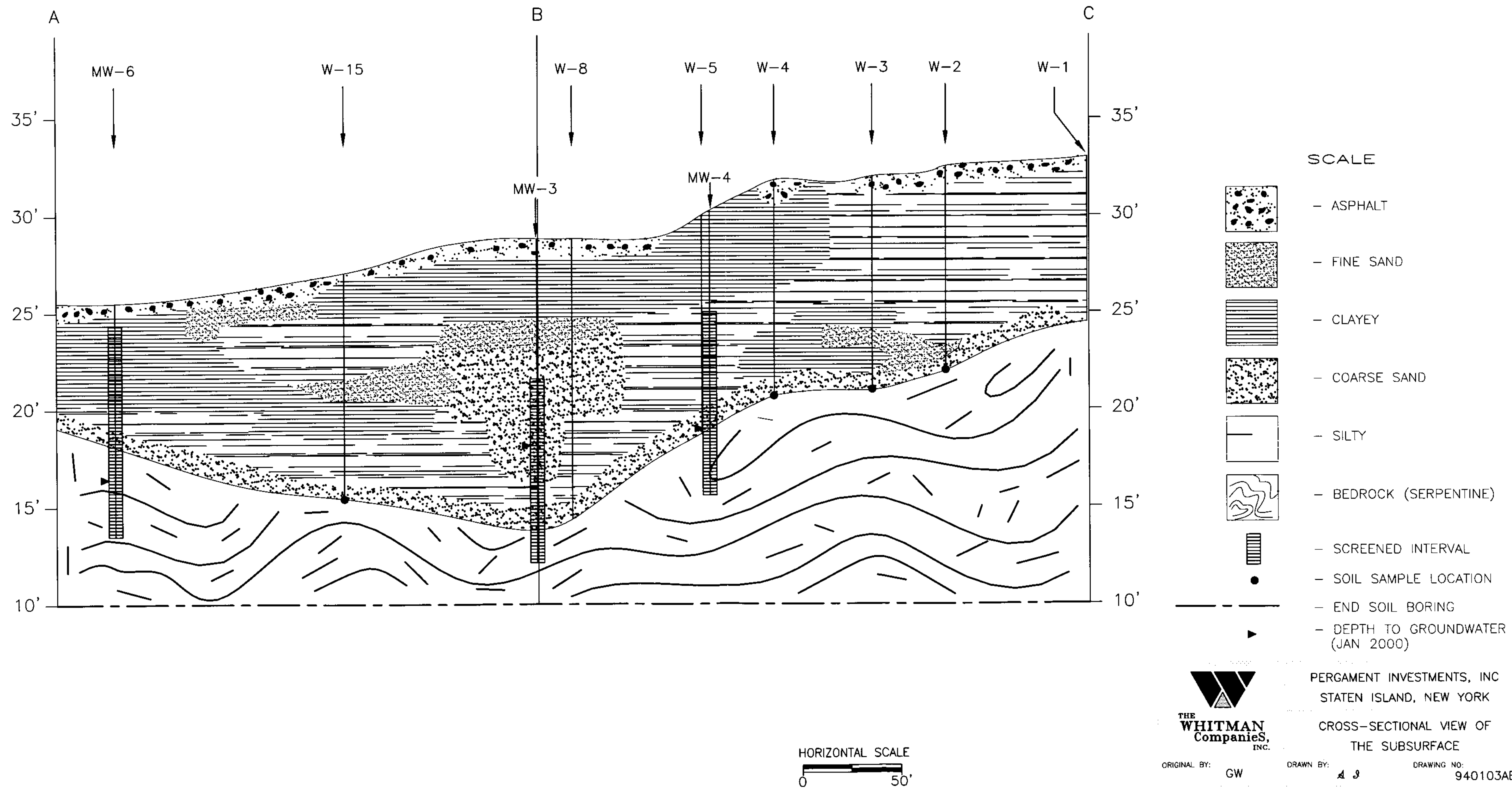
PERGAMENT INVESTMENTS, INC.
STATEN ISLAND, NEW YORK

SURFACE WATER SAMPLING LOCATIONS AND ANALYTICAL RESULTS

ORIGINAL BY: K.M.	DRAWN BY: D.L.	DRAWING NO: 940103-6
CHECKED BY: K.M.	DATE: AUGUST 2000	FIGURE NO: 5


MW-1
COMPOUND µg/L
VOLATILE ORGANIC COMPOUNDS ND
MW-1
FORMER DRY CLEANERS
MW-2
COMPOUND µg/L
cis-1,2-DICHLOROETHENE 40
TRICHLOROETHENE 32
TETRACHLOROETHENE 380
MW-2
MW-4
COMPOUND µg/L
cis-1,2-DICHLOROETHENE 0.7
TRICHLOROETHENE 0.3
TETRACHLOROETHENE 18
MW-4
MW-3
MW-3
COMPOUND µg/L
cis-1,2-DICHLOROETHENE 40
TRICHLOROETHENE 38
TETRACHLOROETHENE 1,200
MW-6
MW-6
COMPOUND µg/L
ETHYLBENZENE 3.6
XYLENE 12
MW-7
MW-7
COMPOUND µg/L
VOLATILE ORGANIC COMPOUNDS ND
MW-5
MW-5
COMPOUND µg/L
CHLOROFORM 2.1
Sign
LEGEND
MW-6 - MONITORING WELL LOCATION
- FENCE & PROPERTY BOUNDARY
18 - COMPOUND CONCENTRATION EXCEEDS NYSDEC GROUND WATER QUALITY CRITERIA
NOTE:
DATUM ESTABLISHED FROM AN ASSUMED BENCHMARK PREVIOUSLY ESTABLISHED BY L.M.S.
SCALE
0
50'
THE WHITMAN CompanieS, INC.
PERGAMENT INVESTMENTS, INC.
STATEN ISLAND, NEW YORK
MONITORING WELL LOCATIONS AND MOST RECENT GROUND WATER SAMPLING RESULTS
ORIG. BY: GW
DWG. BY: TAG
CHK. BY: GW
DWG.#: 940103C4
DATE: AUG. 2000
FIGURE: 6


MW-1 27.83
27.00
26.00
25.00
24.00
23.00
22.00
21.00
20.00
19.00
18.00
17.00
16.00
15.00
14.00
W-1 24.94
W-2 22.51
W-3 20.50
W-4 20.31
W-5 18.92
W-6 17.30
W-7 17.76
W-8 15.75
W-9 14.96
W-10 22.37
W-11 14.29
W-12 14.99
W-13 21.83
W-14 19.70
W-15 14.94
MW-2 15.19
MW-3 15.80
MW-4 17.87
MW-5 13.41
MW-6 19.27
MW-1 19.51
FORMER DRY CLEANERS
A
B
C
Sign
LEGEND
MW-6 19.27 - MONITORING WELL LOCATION W/ BEDROCK ELEVATION
W-15 14.94 - SOIL BORING LOCATION W/ BEDROCK ELEVATION
14.00 - BEDROCK CONTOUR CONTOUR INTERVAL = 1 FOOT
- FENCE & PROPERTY BOUNDARY
- LINE OF GEOLOGIC CROSS-SECTION (FIGURE 6)
NOTE:
DATUM ESTABLISHED FROM AN ASSUMED BENCHMARK PREVIOUSLY ESTABLISHED BY L.M.S.
SCALE
0
50'
THE WHITMAN CompanieS, INC.
PERGAMENT INVESTMENTS, INC. STATEN ISLAND, NEW YORK
BEDROCK CONTOUR MAP WITH SECTION LINE: A-B-C
ORIG. BY: GW
DWG. BY: A 1
CHK. BY: GW
DWG.#: 940103AB
DATE: JULY 2000
FIGURE: 7

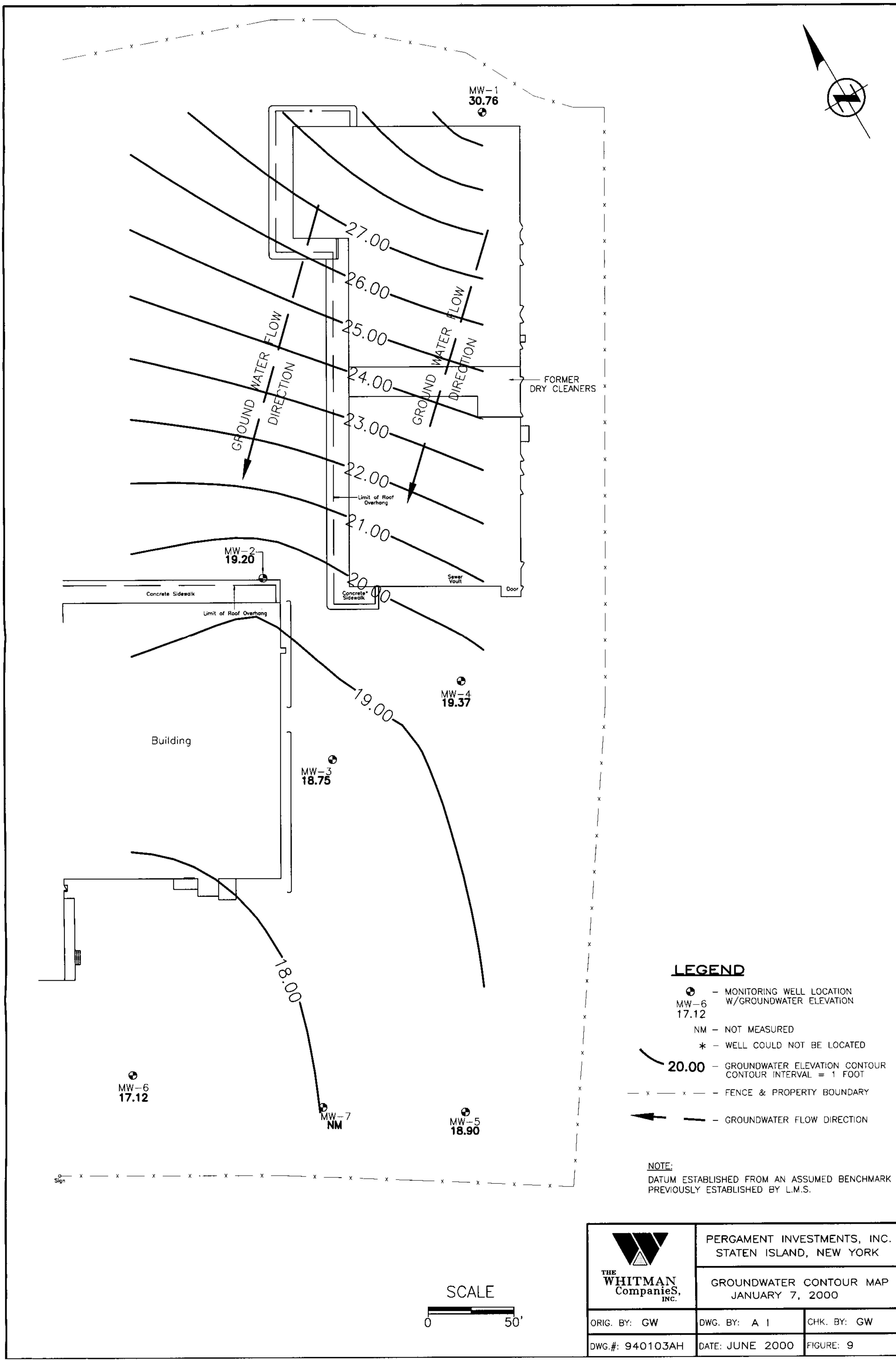


THE WHITMAN CompanieS, INC.

PERGAMENT INVESTMENTS, INC
STATEN ISLAND, NEW YORK

CROSS-SECTIONAL VIEW OF THE SUBSURFACE

ORIGINAL BY: GW	DRAWN BY: A S	DRAWING NO: 940103AE2
CHECKED BY: GW	DATE: JULY 2000	FIGURE NO: 8



MW-1
30.76
27.00
26.00
25.00
24.00
23.00
22.00
21.00
20.00
19.00
18.00
GROUND WATER FLOW DIRECTION
GROUND WATER FLOW DIRECTION
FORMER DRY CLEANERS
Limit of Roof Overhang
Sewer Vault
Door
Concrete Sidewalk
MW-2
19.20
Concrete Sidewalk
Limit of Roof Overhang
MW-4
19.37
Building
MW-3
18.75
MW-6
17.12
MW-7
NM
MW-5
18.90
Sign
LEGEND
MW-6 17.12 - MONITORING WELL LOCATION W/GROUNDWATER ELEVATION
NM - NOT MEASURED
* - WELL COULD NOT BE LOCATED
20.00 - GROUNDWATER ELEVATION CONTOUR CONTOUR INTERVAL = 1 FOOT
FENCE & PROPERTY BOUNDARY
GROUNDWATER FLOW DIRECTION
NOTE:
DATUM ESTABLISHED FROM AN ASSUMED BENCHMARK PREVIOUSLY ESTABLISHED BY L.M.S.
SCALE
0
50'
THE WHITMAN CompanieS, INC.
PERGAMENT INVESTMENTS, INC. STATEN ISLAND, NEW YORK
GROUNDWATER CONTOUR MAP JANUARY 7, 2000
ORIG. BY: GW
DWG. BY: A I
CHK. BY: GW
DWG.#: 940103AH
DATE: JUNE 2000
FIGURE: 9

ATTACHMENT 1

HYDROGEOLOGIC CALCULATIONS

ATTACHMENT 1

HYDROGEOLOGIC CALCULATIONS

1.0 HALF-LIFE CALCULATIONS

1.1 Degradation Half-Lives

The rate of degradation of a biodegradable compound is typically expressed as a half-life ($t_{½}$), that is, the time it takes for a given mass of contaminant to be reduced by 50%. Anaerobic biodegradations half-lives for the contaminants on site are listed below.

CONTAMINANT	**HALF-LIFE ($t_{½}$)**
Tetrachloroethylene	34-230 days
Trichloroethene	33-230 days

The above values are taken from Barbee, 1994, which presents a range of literature value for degradation rates of common chlorinated contaminants. For the purposes of computing contaminant degradation at the site, the highest (most conservative) half-life value was used for each compound.

Since the degradation of most organic compounds in the environment has been shown to be logarithmic, the following first order decay equation was used to calculate the time needed to degrade an initial contaminant concentration to a concentration of interest, such as the NYSDEC ground water standards.

$$t = -\frac{\ln \frac{C}{C_o}}{K},\ Where\ K = \frac{0.693}{t_{1/2}},and$$

Where "C_0" is the contaminant concentration in a particular well, "C" is the NYSDEC ground water standard/criteria for the contaminant of interest, "$t_{½}$" is the compound specific half-life in days, and "t" is the time in days for "C_0" to reach "C"

The most recent sample concentration of PCE in MW-3 (January 2000) was 1200 μg/L. If a conservative half-life value of 230 days is selected for PCE, the time needed to biodegrade PCE to reach a concentration of 5 ppb is calculated to be 1819 or 4.98 years. The calculation is provided below.

$$t = -\frac{\ln \frac{5ppb}{1,200ppb}}{\frac{0.693}{230\ days}} = 1,437\ days$$

The table below show the times calculated for contaminant concentrations to degrade to the appropriate NYSDEC Ground Water Standard /Criteria. Exceedances of the ground water standards during the most recent round of sampling, January 2000, were utilized as initial concentrations (C_0).

TIME FOR CONTAMINANT CONCENTRATIONS TO DEGRADE TO NYSDEC GROUND WATER STANDARDS

Contaminant	Initial Conc. (C_0)	Date of Most Recent Exceedance of NYSDEC Standard	Half-Life ($t_{½}$)	Time (t) to Degrade to NYSDEC Standard
MW-2				
Trichloroethene	32 µg/L	January 2000	230 days	616 days
Tetrachloroethylene	380 µg/L	January 2000	230 days	1437 days
MW-3				
Trichloroethene	38 µg/L	January 2000	230 days	730 days
Tetrachloroethylene	1,200 µg/L	January 2000	230 days	1819 days
MW-4				
Tetrachloroethylene	18 µg/L	January 2000	230 days	424 days

1.2 Distance Contaminants Are Predicted To Travel Before Reaching NYSDEC Ground Water Standards / Criteria

To determine how far the contaminant will migrate during the period of time needed to degrade from its initial concentration (C_0) to a concentration below its respective ground water quality criteria, the length of transport, "d", is calculated by the following equation:

$$d = V_{pt} \times t$$

Where "d" is the distance the contaminant will travel, "V_{pt}" is the pollutant transport rate, and "t" is the time to reach the concentration of interest.

Using "t" as the time to reach the ground water criteria and the pollutant transport rate calculated for each compound in section 5.2, the distance of downgradient contaminant migration, "d", for the chlorinated compounds is shown below.

DISTANCE CONTAMINANTS WILL MIGRATE BEFORE REACHING NYSDEC STANDARDS

Contaminant	Initial Conc. (C_0)	Date*	Time, t, for initial concentration to degrade to NYSDEC Standard	Pollutant Transport Rate (V_{pt}) (ft/day)*	Distance, d, that plume would travel before reaching NYSDEC Standard
MW-2					
Trichloroethene	32 µg/L	Jan 00	616 days	0.04	24.6 feet
Tetrachloroethylene	380 µg/L	Jan 00	1437 days	0.03	43.1 feet
MW-3					
Trichloroethene	38 µg/L	Jan 00	730 days	0.04	29.2 feet
Tetrachloroethylene	1,200 µg/L	Jan 00	1819 days	0.03	54.6 feet
MW-4					
Tetrachloroethylene	18 µg/L	Jan 00	424 days	0.03	12.7 feet

* **Previously calculated and presented in Remedial Investigation Report (August 1998)**

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