

**OVERVIEW OF THE PETREX PASSIVE  
SOIL GAS TECHNIQUE - TWO CASE STUDIES**

Mostafa El Sehamy, P.G., C.G.W.P.  
*Fenley & Nicol Environmental, Inc.*  
445 Brook Avenue  
Deer Park, New York 11729

David T. Jacobs, Jr.  
*Miller Environmental Group Inc.*  
538 Edwards Avenue  
Calverton, NY 11933

**ABSTRACT**

The authors have combined experience with the Petrex passive soil gas survey technique at several sites in New York City and Long Island. This paper discusses passive soil gas surveys performed at two selected sites in New York City and Long Island, New York. The Petrex soil gas surveys for these two case studies were performed to identify potential source areas of petroleum hydrocarbons in the soil gas, map the areal extent of the identified compounds in order to determine areas of potential subsurface contamination, and attempt to determine the extent of migration of the identified compounds in the subsurface.

In addition to identifying potential source areas, Petrex soil gas surveys are also used as an initial site screening tool to limit the amount, and aid in the placement of, soil borings and monitoring wells with the cost benefit associated with reduced drilling and analytical expenses.

This extended abstract compares the results of the Petrex soil gas surveys to the quantitative results of groundwater analyses from monitoring wells at both sites and discusses the advantages and disadvantages of the technique for initial site screening.

**Introduction to the Petrex Technique**

Each Petrex soil gas sampler consists of two or three activated charcoal adsorption elements (collectors) housed in a resealable glass container in an inert atmosphere.

Soil gas sample collection is performed by unsealing the sampler and exposing the collector to the subsurface soil gas at the base of a shallow borehole, generally 12" to 24" in depth. Sample collection proceeds via free vapor diffusion through the opening of the uncapped sampler container. Following a controlled period of time, typically two to three weeks, the sampler is retrieved from the borehole, resealed, and submitted for analysis.

One collector from each soil gas sampler is analyzed by Thermal Desorption-Mass Spectrometry (TD-MS). Selected second collectors may be analyzed by Thermal Desorption-Gas Chromatography/Mass Spectrometry (TD-GC/MS) for compound confirmation. At least 10% of samplers used in any project have three collectors. The third collector is used for setting instrument sensitivity prior to analysis.

### **Discussion of Petrex Technique**

Petrex response values are reported in ion counts. Ion count values are the unit of measure assigned by mass spectrometers to the relative intensities associated with each of the reported compounds. These intensity levels or response levels do not represent an actual concentration of the reported compounds; however, they are best utilized as a qualitative measurement. A difference in ion count values of an order of magnitude, or more is considered significant when interpreting potential source areas and migration/dispersion pathways versus background areas.

Soil gas data collected with the Petrex technique reflect volatile and semi-volatile organics collected at a point near the ground surface. The sources of these vapor phase organics may be light non-aqueous phase liquids (LNAPL) floating on the groundwater, residual petroleum hydrocarbons above the groundwater table, and/or dissolved phase petroleum hydrocarbons in the groundwater. Petrex soil gas surveys are conducted for revealing the areal extent of contamination and for identifying areas that may require vertical profiling, including the drilling of soil borings and monitoring wells.

Because soil gas emanation rates are site and chemical specific, the environmental significance of the soil gas response values must be determined relative to compound concentrations in subsurface soil and/or groundwater. Changes in soil gas response (in orders of magnitude) may be used to plan future investigative studies and to aid in characterizing the behavior (migration, attenuation) of the chemicals in the subsurface. The Petrex method is extremely sensitive and often detects compounds in the low part per billion (ppb) range; therefore areas depicted as background by the PETREX method may not represent environmentally significant contaminant levels in the subsurface.

## **SITE 1**

### **Background History**

The subject site is a service station located on NYS Route 25, Suffolk County, New York (See Figure 1). The subsurface investigation was initiated for this site after several residents in the area complained of petroleum odors in their homes. These homes were located down gradient from the spill source.

### **Site Geology and Hydrogeology**

The subject site is underlain by the upper glacial aquifer. The upper glacial aquifer consists of unconsolidated highly permeable, brown, medium to coarse-grained sand and gravel. Groundwater at the site flows in a south-southeasterly direction toward the residential area. The hydraulic conductivity of the aquifer in the vicinity of the site was measured at 62 feet/day using rising head data from monitoring well slug test analyzed with the Bower-Rice equation.

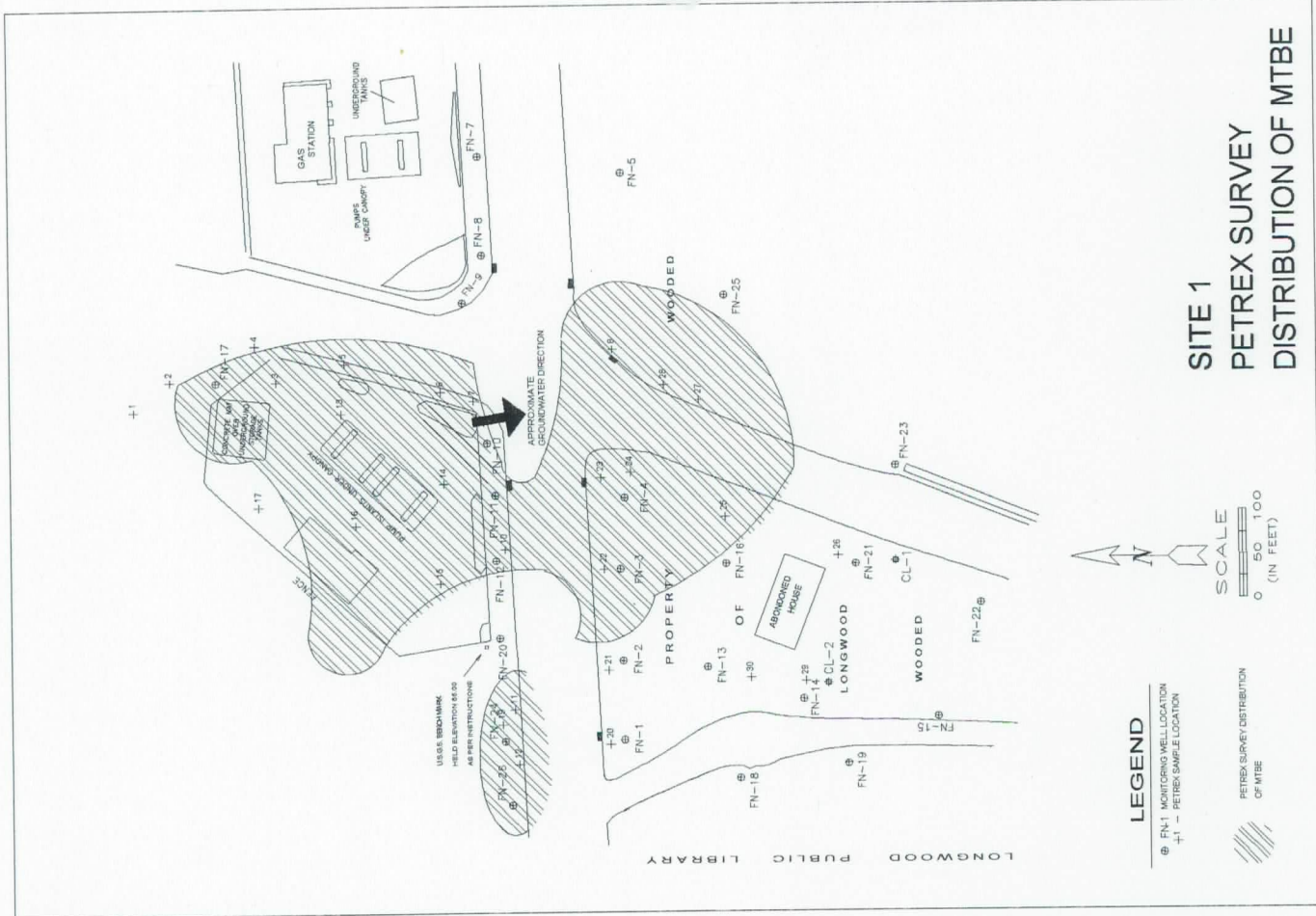


FIGURE 2

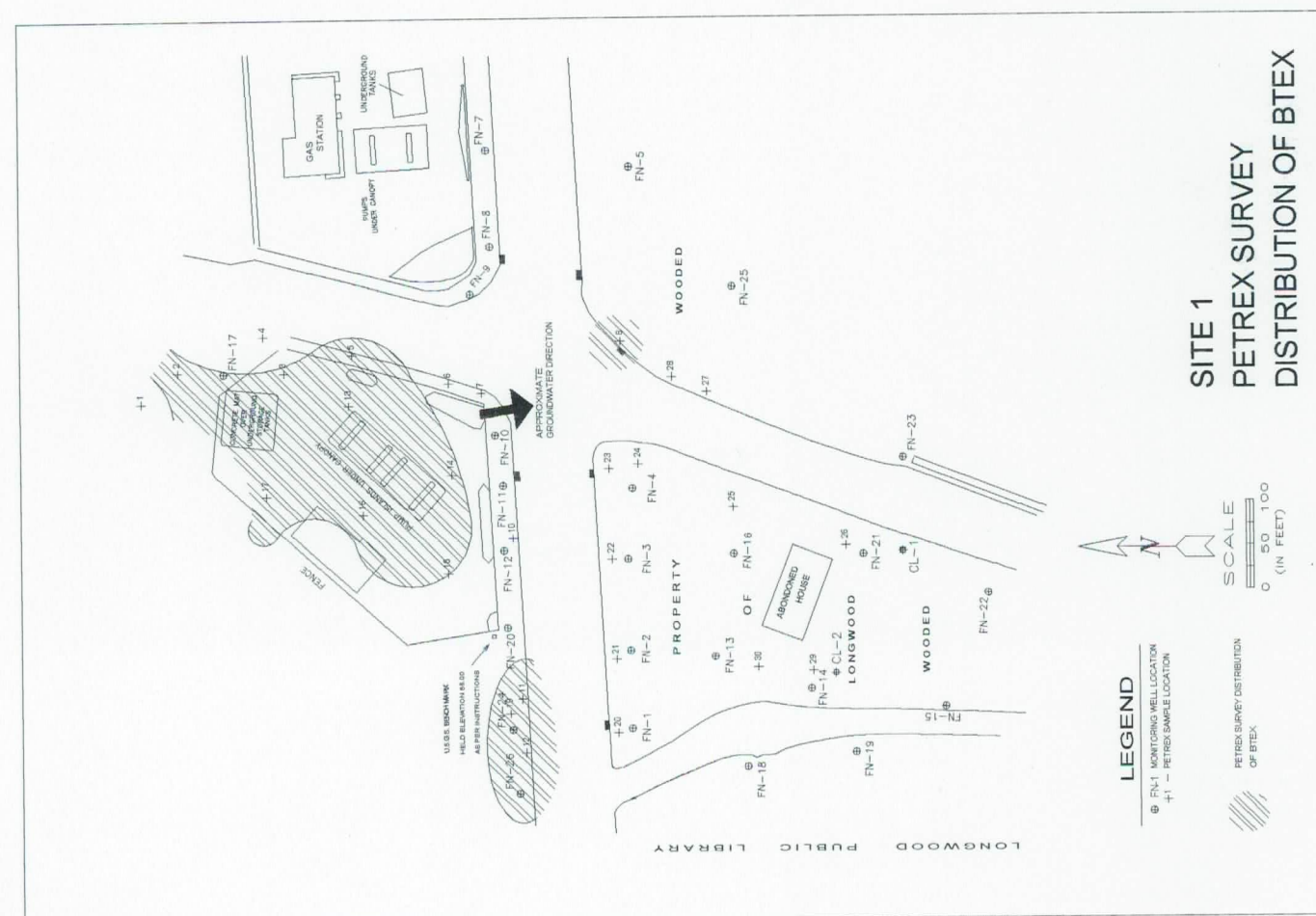


FIGURE 1

### Passive Soil Gas Survey

A total of 30 Petrex soil gas samplers were utilized at *Site 1* (See Figure 1). All samplers were analyzed using TD-MS. The C<sub>6</sub>-C<sub>10</sub> aromatic hydrocarbons, which include benzene, toluene, ethyl benzene and xylene (BTEX) and C<sub>4</sub>-C<sub>10</sub> non-aromatic hydrocarbons were the primary constituents detected in the soil gas. Since the spill source was gasoline, BTEX and methyl tert butyl ether (MTBE) were the only compounds analyzed for and mapped as part of the Petrex soil gas survey. The soil gas discussion will be limited to aromatic hydrocarbons inclusive of BTEX and MTBE.

Quantitative analysis of groundwater from monitoring wells FN-1 through FN-5 (see Figure 1) indicated the presence of dissolved BTEX and MTBE. Table 1 lists groundwater concentrations for dissolved total BTEX and MTBE at monitoring wells FN-1 through FN-4 and soil gas response levels from Petrex samplers closest to each respective monitoring well for the C<sub>6</sub>-C<sub>10</sub> aromatic hydrocarbons, which include BTEX, plus MTBE. In some cases more than one Petrex sampler is listed per monitoring well location since more than one sampler was in the immediate vicinity of a well. Petrex samplers were not installed in the vicinity of monitoring well FN-5. The distribution of BTEX and MTBE (indicated by Petrex samples) were mapped and are displayed in Figures 1 and 2.

**TABLE 1**  
**Dissolved Phase and Passive Soil Gas Results at Site 1**

Monitoring Well	Soil Gas Sampler	Total BTEX		MTBE	
		Dissolved Phase (ppb)	Relative Response (Ion Counts)	Dissolved Phase (ppb)	Relative Response (Ion Counts)
FN-1	20	639	25,421	7.2	17,472
FN-2	21	ND	49,838	250	9,670
FN-3	22	1,140	72,992	5.2	145,138
FN-4	23	11,958	ND	51	10,952
	24	-	43,212	-	22,789

NS - Not Sampled

ND - Not Detected

It can be seen from Table 1 that soil gas samplers installed in areas near monitoring wells FN-1, FN-3 and FN-4 corroborated the presence of aromatic hydrocarbons in that high ion counts were registered. However, no correlation was detected between the magnitudes of total BTEX concentrations and ion counts. The Petrex method for this case study is limited to qualitative confirmation of the presence of BTEX compounds in the subsurface. For example, even though the concentration of total BTEX in water was lowest at monitoring well FN-2

(non-detect) the ion counts for the Petrex samplers were relatively high. During the installation of the wells a flame ionizing detector (FID) was used to screen the vertical soil column in the unsaturated zone. No vapor phase organics were detected at any of the well locations indicating that the high relative ion counts were not an indication of residual phase hydrocarbons in the unsaturated zone.

In addition to qualitatively confirming the presence of BTEX compound in the subsurface in the vicinity of wells FN-1 through FN-4, the PETREX survey identified significantly higher ion response near the underground tanks and pump islands (See Figure 1).

## **SITE 2**

### **Background History**

The site is located on 10th Avenue, Manhattan, New York (See Figure 2). The subsurface investigation for this site was conducted after several complaints of gasoline vapors detected in the basement of the building on the north west corner. Several monitoring wells were installed to define the source or migration paths and were utilized for soil gas venting to prevent vapor from entering the basement.

### **Site Geology and Hydrogeology**

The site is underlain by approximately 7 feet of unconsolidated sandy fill material with pebbles and silty sand. Beneath this layer is a light brown fine sand with pebbles and occasional boulders. Bedrock is encountered at depths of approximately 18 feet. Groundwater at the site occurs at a depth of 17 feet. The groundwater is flowing in a northerly direction. Hydraulic conductivity was calculated by performing a slug test at 0.45 feet/day.

### **Passive Soil Gas Survey**

A total of 30 PETREX soil gas samplers were utilized at *Site 2* (see Figure 3). All Petrex samplers were analyzed by TD-MS. BTEX and MTBE were the primary constituents detected in the soil gas. The distributions of BTEX and MTBE were mapped and are displayed in Figure 3 and 4.

Moderate to relatively high ion counts of BTEX were detected around the gas station and brake shop. One moderate BTEX ion count is shown on the northeast corner of the school yard (Figure 3).

MTBE was detected at location 2 on the gas station; at location 18 near the brake shop; and at locations 23, 24 and 28 on the school yard corner (Figure 4).

Table 2 list groundwater concentrations for total BTEX and MTBE at monitoring wells FN-9, FN-11 and FN-12 through FN-15, and soil gas response levels from Petrex samplers which were closest to each respective monitoring well. In some cases more than one Petrex sampler is listed per monitoring well location since more than one sampler is in the immediate vicinity of well.

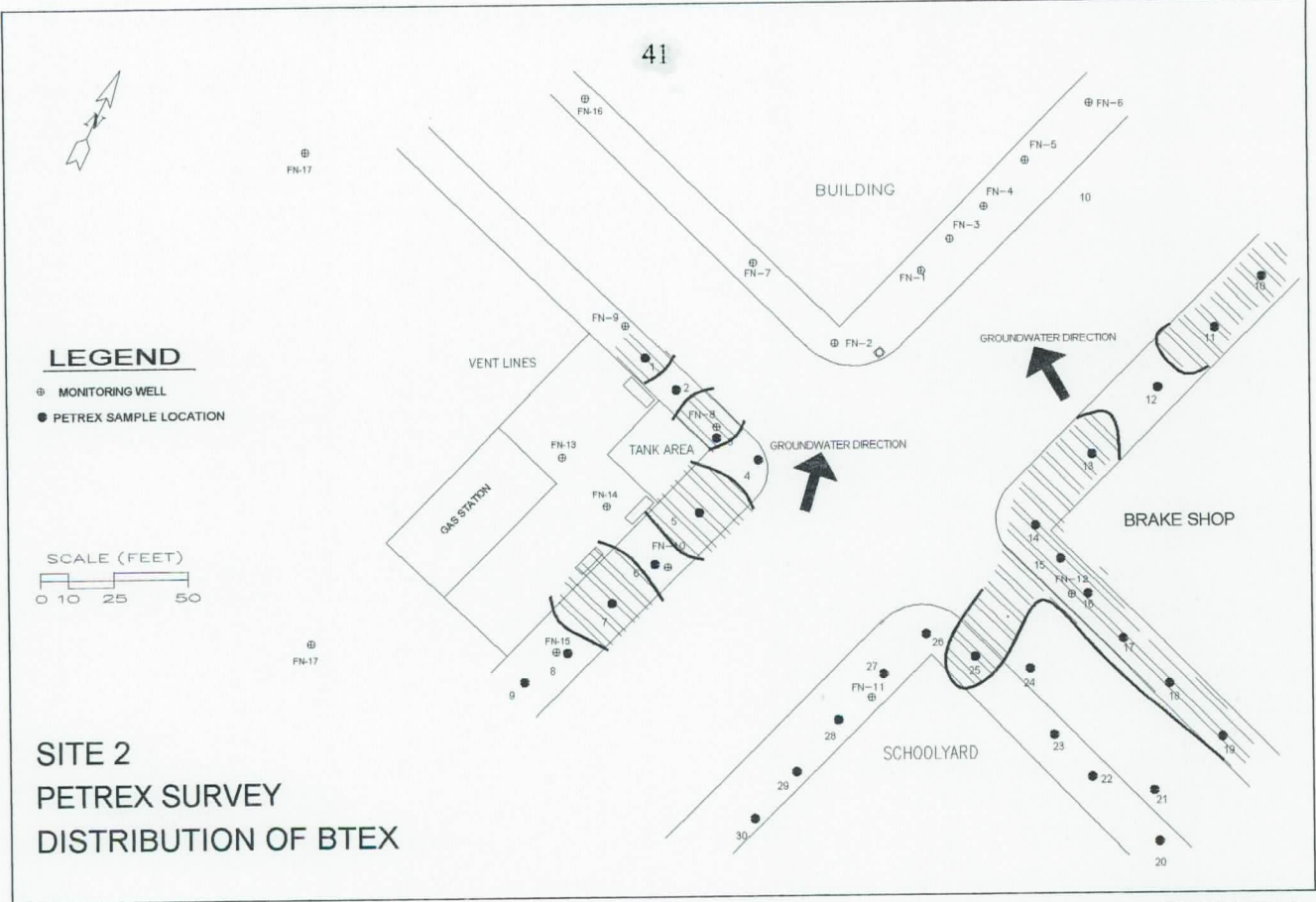


FIGURE 3

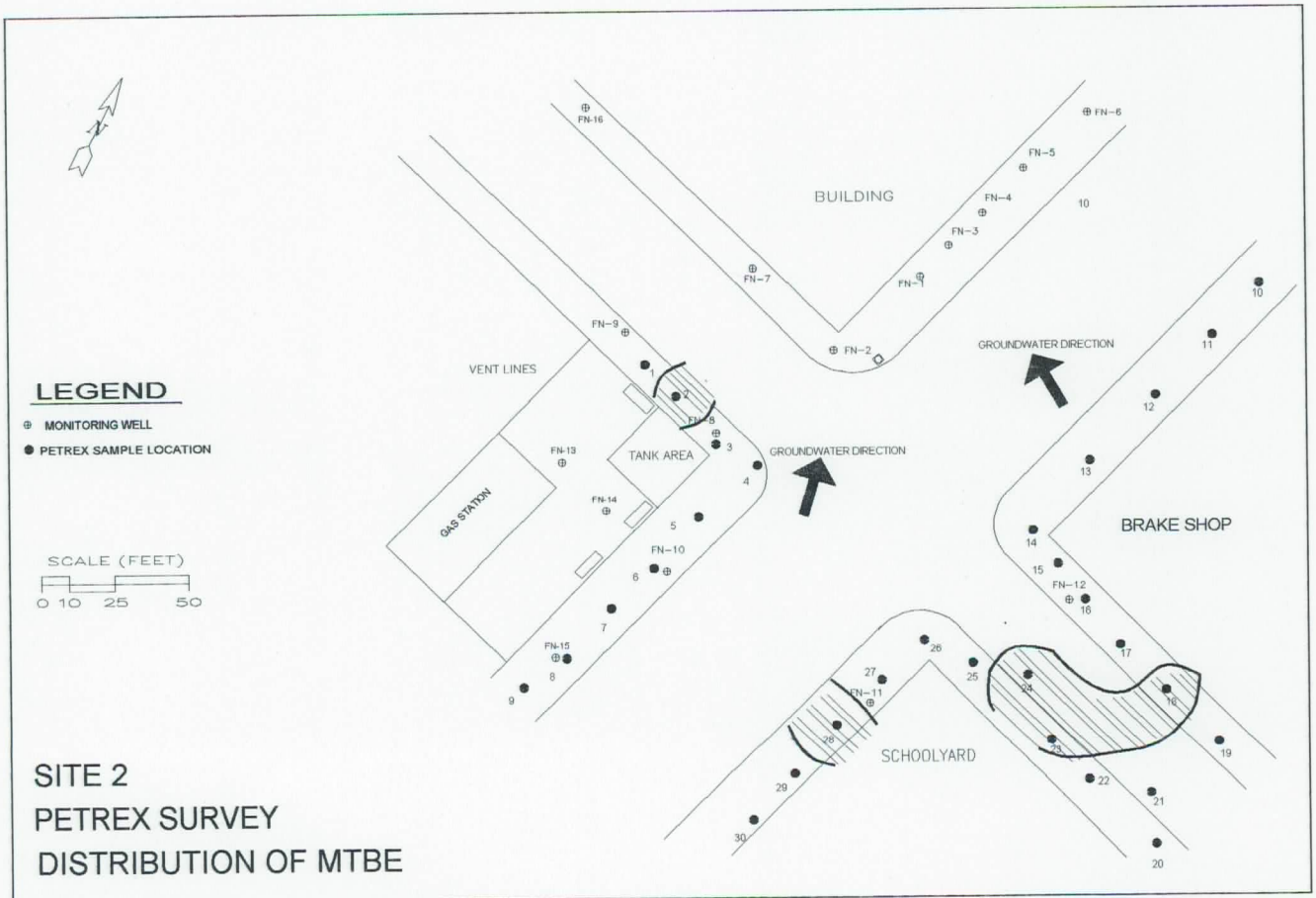


FIGURE 4

**TABLE 2**  
**Dissolved Phase and Passive Soil Gas Results at Site 2**

Monitoring Well	Soil Gas Sampler	Total BTEX		MTBE	
		Dissolved Phase (ppb)	Relative Response (Ion Counts)	Dissolved Phase (ppb)	Relative Response (Ion Counts)
FN-9	1	ND	611,498	850	470,381
FN-11	27 28	ND	8,929 24,496	ND	35,123
FN-12	15 16 17	ND	384,100 6,953,390 982,300	520	ND ND ND
FN-13	NS	ND	-	1,600	-
FN-14	NS	257	-	1,000	-
FN-15	8 9	5	116,073 11,315	510	27,357

NS - Not Sampled

ND - Not Detected

Concentrations of BTEX detected in groundwater were low to non-detect in monitoring wells for which Petrex samples were installed nearby. However, Petrex soil gas sampler results show high ion counts in all samples. During the installation of the wells a photo ionizing detector (PID) was used to screen the vertical soil column in the unsaturated zone. No vapor phase organics were detected at any of the well locations indicating that the high relative ion counts were not an indication of residual phase hydrocarbons in the unsaturated zone. This indicates that the vapor phase hydrocarbons present in these areas do not come from LNAPL, residual or dissolved phase hydrocarbons in this area. Concentrations of dissolved MTBE and ion counts in the soil gas are also not in agreement.

### Conclusions

The results obtained from the Petrex Soil Gas Survey performed at *Site 1* provide qualitative agreement with the known source areas of aromatic hydrocarbons and selected monitoring wells. No correlation between groundwater sampling results and ion counts appear to be evident in this particular instance.

The Petrex Soil Gas Survey performed at *Site 2* did not agree qualitatively or quantitatively with dissolved phase hydrocarbons measured in the groundwater.

Many factors complicate the interpretation of passive soil gas survey data. It cannot be determined from ion counts if vapor phase hydrocarbons partitioned from the liquid, dissolved or residual phase, or a combination of phases. Vapor phase hydrocarbons are free to migrate through the unsaturated porous medium away from source areas much like dissolved phase hydrocarbons in the saturated zone, however; the flow field in the unsaturated zone is not as uniform in velocity or direction as typically observed in the saturated zone.

Flow and dispersion of vapor phase organics in the unsaturated zone can be influenced by many factors: changes in barometric pressure, surface features such as concrete or asphalt cover, remediation equipment, such as soil venting and sparging, geologic features, such as clay lenses and bedrock, subsurface cultural features, such as sewers, water mains, Subway tunnels with pressure differentials caused by passing trains and basements with pressure differentials caused by venting systems and elevator shafts, especially in Manhattan.

If the velocity of air moving through the porous medium is fast enough, migration of vapor phase organics away from source areas (LNAPL, residual or dissolved phase) may exceed the rate at which they partition into the vapor phase.

Petrex Soil Gas Surveys, when utilized as an initial site screening tool, can aid in the placement of soil borings and monitoring wells. They can detect anything present in the soil gas down to the low parts per billion that can be analyzed by TD-MS. However, great care is needed in designing surveys and interpreting the data. When investigations are performed to determine responsible parties, passive soil gas surveys may provide ambiguous results and complicate legal strategies. Because of the lack of quantitative correlation witnessed between monitoring well data and Petrex results, it is advisable that Petrex surveys be augmented with monitoring well, GeoProbe and/or active soil gas data to provide quantitative checks and act as reference points for the Petrex results.