TECHNICAL MEMORANDUM

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Subject: Draft Evaluation Report for the Mulch Biowalls at the Ash Landfill Site, Seneca Army Depot Activity, Romulus, New York

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This Evaluation Report assesses the monitoring results for enhanced *in-situ* bioremediation of chlorinated solvents via two mulch biowalls at the Ash Landfill at Seneca Army Depot Activity, Romulus, New York. In accordance with the Record of Decision (ROD) for this site, the selected remedy includes installation of three in situ permeable reactive walls for the treatment of groundwater. The use of reactive walls containing zero-valent iron (ZVI) has been assessed at the site in the past (Parsons, 2000). This Evaluation Report assesses the performance of reactive walls containing mulch to enhance biodegradation. The performance of the mulch biowalls is compared to the performance of the ZVI wall, as outlined in the Ash Landfill Biowall Pilot Study Work Plan (Parsons, 2005).

This Report summarizes data collected by Parsons for the four rounds of sampling in September, 2005, October, 2005, December, 2005 and January 2006. Two permeable mulch biowalls were installed in July 2005 in accordance with the Ash Landfill Biowall Pilot Study Work Plan (Parsons, May 2005).

1 INTRODUCTION

Solid-phase organic substrates used to stimulate anaerobic biodegradation of chlorinated ethenes include plant mulch and compost. Mulch may be composted prior to emplacement, or the mulch may be mixed with another source of compost, to provide active microbial populations for further degradation of the substrate in the subsurface. Mulch is primarily composed of cellulose and lignin, but "green" plant material is incorporated to provide a source of nitrogen and nutrients for microbial growth. These substrates are mixed with coarse sand and emplaced in a trench or excavation in a permeable reactive biowall configuration. Biodegradable vegetable oils may also be added to the mulch mixture to increase the availability of soluble organic matter. This treatment method relies on the flow of groundwater under a natural hydraulic gradient through the biowall to promote contact with slowly-soluble organic matter. As the groundwater flows through the organic matter within the biowall, a treatment zone is established not only within the biowall, but downgradient of it, as the organic matter migrates with the groundwater and microbial processes are established.

Degradation of the organic substrate by microbial processes in the subsurface provides a number of breakdown products, including metabolic acids (e.g., butyric and acetic acids). The breakdown products and acids produced by degradation of mulch in a saturated subsurface environment provide secondary fermentable substrates for generation of hydrogen, the primary electron donor utilized in anaerobic reductive dechlorination of chlorinated ethenes. Thus, a mulch biowall has the potential to stimulate reductive dechlorination of chlorinated ethenes for many years. If needed, mulch biowalls can be periodically recharged with liquid substrates (e.g., vegetable oils) to extend the life of the biowall. In addition to the application at Seneca Army Depot, mulch biowalls for degradation of chlorinated ethenes also have been installed at Altus AFB, Oklahoma, Offutt AFB, Nebraska (Haas et al., 2000 and 2003; Aziz et al., 2001 and 2003), F.E. Warren AFB, Wyoming (Parsons, 2004), and Naval Weapons Industrial Reserve Plant, McGregor, Texas (Cowan, 2000).

Reductive dechlorination is the most important process for natural biodegradation of the more highly chlorinated solvents (EPA, 1998) and is shown in **Figure 1**. Complete dechlorination of TCE and the other chlorinated solvents present in the groundwater is the goal of anaerobic biodegradation using the mulch biowall technology.

1.1 Objective

Two parallel permeable mulch biowalls were installed at the Ash Landfill site at the Seneca Army Depot in July 2005 to stimulate anaerobic biodegradation of chlorinated ethenes in groundwater on a pilot-scale level. In particular, the two biowalls were installed across the path of groundwater flow near the TCE plume source to demonstrate that a mulch biowall would be equally as effective as a permeable reactive iron (ZVI) wall in promoting the *in-situ* bioremediation of trichloroethene (TCE) and *cis*-1,2-dichloroethene (cDCE) in groundwater (see **Figure 2**). The objective of the future full-scale biowall application is to treat a shallow groundwater plume contaminated with TCE, cDCE and VC in order to prevent off-depot migration. The biowall is composed of shredded leaves, bark and wood mulch, and sand (to maintain permeability). The mulch and compost substrates are intended to be used as solid-phase, long-term carbon sources to stimulate anaerobic degradation of chlorinated ethenes.

Two parallel walls were installed to represent two separate scenarios. Each individual wall could be assessed on its own with the most upgradient wall treating the highest concentration groundwater and the second wall treating lower concentrations. Secondly, the walls could be assessed as a dual wall system.

Specifically, the pilot study was performed to demonstrate the following:

- Achievement of similar reduction of concentrations of TCE within the biowall as was demonstrated for the ZVI PRB described in the Feasibility Memorandum (Parsons, 2000).

- A reduction in total molar concentrations of chlorinated ethenes in the biowalls and at monitoring locations downgradient of the biowalls. One metric used to evaluate biowall effectiveness in meeting this performance objective was to demonstrate that the treatment efficiency achieved by the biowalls was equal to or greater than the percent molar reductions observed for the ZVI pilot-scale treatability study. The method used to evaluate this metric was to compare total molar chlorinated ethene concentrations at upgradient monitoring wells with those observed within the second biowall at downgradient monitoring wells. This is a slight change from the pilot study work plan in that the walls were evaluated as a dual wall system rather than individually. Results from this biowall pilot study were compared to the molar reduction results that were calculated from concentration measurements performed over time from monitoring wells in and around the ZVI PRB.

- That the biowalls create a treatment zone within and downgradient of the trenches that is favorable to the long-term enhancement of degradation of TCE and its regulated intermediate degradation products, *cis*-1,2-DCE, *trans*-1,2-DCE and VC. This performance objective was demonstrated through the evaluation of the groundwater geochemical conditions that are created within and downgradient of the biowall, and comparison of these conditions to sites where other biowalls have been installed. The long-term goal of constructing multiple biowalls is to degrade chlorinated ethenes to concentrations below the NYSDEC GA standards.

- That no chlorinated solvents will exceed NYSDEC GA Standards at the Farm House west of the site at any time during the estimated remediation timeframe.

- Evaluate biowall design criteria (e.g., organic carbon generation, degradation rates, residence time) and constructability issues (e.g. trenching techniques, trench stability, oil application, and subsurface pipe placement) required for effective long-term operation.

This report shows that the pilot study objectives have been met and the Army intends on submitting a remedial design work plan incorporating this technology.

1.2 Scope of Work

Site-specific activities conducted at the Ash Landfill in support of the enhanced bioremediation field application include:

- Installation from July 18 to July 22, 2005 of two parallel 150-foot-long, by 11-foot-deep, by 3.0-foot-wide mulch biowalls composed of shredded leaf, bark and wood mulch, and sand. The mulch/sand mixture in the easternmost wall was coated with soy bean oil prior to placement in the trench;

- Installation of 11 groundwater monitoring wells on August 11, August 12 and August 22, 2005;

- Post-installation sampling of groundwater at the newly installed monitoring wells and existing monitoring well PT-12A in September 7-12, 2005 (Round 1), October 24-26, 2005 (Round 2), December 12-16, 2005 (Round 3) and January 24-28, 2006 (Round 4); and

- Aquifer testing (hydraulic conductivity) of the newly installed monitoring wells.

Groundwater samples were collected after installation of the biowall and were analyzed for chlorinated solvents and their dechlorination products, dissolved oxygen (DO), nitrate, nitrite, ferrous iron, manganese, sulfate, sulfide, carbon dioxide, methane, ethane, ethene, oxidation-reduction potential (ORP), alkalinity, pH, temperature, specific conductance, total organic carbon (TOC), volatile fatty acids (VFAs), and chloride.

2 SITE DESCRIPTION

The Ash Landfill site was initially estimated to encompass an area of approximately 130 acres. This larger area was investigated to ensure that no previously unknown waste disposal areas were overlooked. Following the remedial investigation, the area of the Ash Landfill site was refocused to an area of approximately 23 acres. This area is comprised of five Solid Waste Management Units (SWMUs) including: Incinerator Cooling Water Pond (SEAD-3), the Ash Landfill (SEAD-6), the Non-Combustible Fill Landfill (NCFL) (SEAD-8), the Refuse Burning Pits (SEAD-14), and the Abandoned Solid Waste Incinerator Building (SEAD-15). The Debris Piles are located near SEAD-14. The Ash Landfill (SEAD-6) also includes a groundwater plume that emanates from the northern western side of the landfill area. The groundwater plume extends 1,100 feet from the original source area to the western depot property line. The plume consists of chlorinated ethenes (TCE, DCE, etc.).

An RI/FS investigation was completed in 1996. A Non-Time Critical Removal Action (NTCRA), also known as an Interim Removal Measure (IRM), was conducted by the Army between August 1994 and June 1995, under the requirements of the CERCLA to remove the source area. This source removal action involved the excavation of 63,000 cubic yards of soil and treatment using Low Temperature Thermal Desorption. The surface area involved approximately 1.5 acres.

The IRM thermal treatment project provided a positive benefit for the long-term remedial action by eliminating continued leaching of VOCs into groundwater and preventing further exposure to humans and wildlife. In the several years that have passed since the IRM, the positive benefits of the IRM have been observed as the concentration of groundwater in this area has decreased over 100-fold.

A zero valence iron (ZVI) treatability study was performed between 1998 and 2001 and showed that the permeable wall would degrade chlorinated ethenes. Based on good performance data from the ZVI treatability study, a 650 foot by 15 foot by 14-inch wide trench was excavated near the depot property line and backfilled with a 50/50 mix of zero valent iron and sand. A performance monitoring well network was sampled and analyzed from 1999 to 2004 to assess the performance of the wall. A ROD for this site was subsequently issued in February 2005 and included the use of permeable walls as migration control for the groundwater contamination on site.

The site is underlain by a broad north-to-south trending series of rock terraces covered by a mantle of glacial till. As part of the Appalachian Plateau, the region is underlain by a tectonically undisturbed sequence of Paleozoic rocks consisting of shales, sandstones, conglomerates, limestones and dolostones. At the Ash Landfill site, these rocks (the Ludlowville Formation) are characterized by gray, calcareous shales and mudstones and thin limestones with numerous zones of abundant invertebrate fossils. Locally, the shale is soft, gray, and fissile. Pleistocene age (Late Wisconsin age, 20,000 years before present [bp]) till deposits overlie the shales, which have a thin (2 to 3 feet) weathered zone at the top. The till matrix varies locally, but generally consists of unsorted silt, clay, sand, and gravel. At the Ash Landfill Operable Unit, the thickness of the till generally ranges from 4 to 15 feet. At the location of the biowalls, the thickness of the till and weathered shale is approximately 10 to 15 feet.

Groundwater is present in both the shallow till/weathered shale and in the deeper competent shale. In both water-bearing units, the predominant direction of groundwater flow is to the west, toward Seneca Lake. Based on the historical data, the wells at the Ash Landfill site exhibit rhythmic, seasonal water table and saturated thickness fluctuations. The saturated interval is at its thinnest (generally between 1 and 3 feet thick) in the month of September and is the thickest (generally between 6 and 8.5 feet thick) between the months of December and March.

The average linear velocity of the groundwater in the till/weathered shale was calculated during the RI using the following parameters: 1) an average hydraulic conductivity of 4.5×10^{-4} centimeters per second (cm/sec) (1.28 feet per day [ft/day]), 2) an estimated effective porosity of 15% (0.15) to 20% (0.20), and 3) a groundwater gradient of 1.95×10^{-2} foot per foot (ft/ft) (Parsons Engineering Science, Inc. [ES], 1994a). The average linear velocity was calculated to 0.166 ft/day or 60.7 feet per year (ft/yr) at 15% effective porosity and 0.125 ft/day or 45.5 ft/yr at 20% effective porosity. The actual velocity on-site may be locally influenced by more permeable zones possibly associated with differences in the actual porosity of the till/weathered shale.

The average linear velocity of the groundwater in the competent shale was calculated using the following parameters: 1) an average hydraulic conductivity of 3.73×10^{-5} cm/sec (0.106 ft/day), 2) an estimated effective porosity of 6.75% (0.0675), and 3) a groundwater gradient of 2.5×10^{-2} ft/ft. An average linear velocity of 3.9×10^{-2} ft/day or 14.3 ft/yr was calculated for the competent shale.

TCE and the dichloroethene isomer cDCE are the most prevalent chlorinated ethenes in both extent and concentration in groundwater at the Ash Landfill. The area extent of TCE based on groundwater samples collected in January 2000 is illustrated in **Figure** 2. Subsequent monitoring has shown little change since then. The TCE plume originates from the Ash Landfill and extends west approximately 1,000 feet to the Depot's western boundary. Concentrations of total chlorinated ethenes in January ranged up to 2,088 micrograms per liter (μg/L). The plume is bounded to the west by the monitoring well (MW-56) located on the adjacent property as evidenced by historic sampling. The plume is currently controlled by the 650 foot long permeable reactive wall installed upgradient of the depot property line.

3 BIOWALL CONSTRUCTION

Two biowalls were constructed perpendicular to the path of groundwater flow in the vicinity of monitoring well PT-12A as shown on **Figure** 2. The selected area for installation has shown the highest concentrations of chlorinated ethenes. The biowalls were constructed to demonstrate the technology could be as effective as the existing zero-valent iron wall in reducing chlorinated ethene concentrations. The eastern biowall is 150-foot-long and averages 11.3 feet deep, by 3-foot-wide. The western biowall is 150-foot-long and averages 10.7 feet deep, by 3-foot-wide. The walls were installed 15 feet apart by Sessler Wrecking of Waterloo, New York. A total mix of 200 cubic yards of shredded mulch and 150 cubic yards of sand was backfilled in the trenches to form the biowalls. The mulch/sand mix for the western biowall was coated with 880 gallons of soybean oil prior to placement to evaluate if it would enhance the effectiveness of the mulch mixture. Additionally, a 3-inch HDPE pipe was installed in the western biowall for future injection of soybean oil if required. The mulch consisted of shredded plant material (a mix of whole deciduous and evergreen trees).

An excavator was employed to excavate the trench for the biowall. The excavator utilized rock teeth to properly key the bottom of the trench through the fractured bedrock into the competent bedrock. The backfill material was placed in the trench using a loader. Soil generated during excavation of the biowalls was piled next to the installed biowall. The final disposition of the soil will be dependent on the TCE concentrations as discussed in the pilot study work plan. The location and extent of the biowall is marked with metal fence posts painted a high visibility color.

Following construction of the biowall, 11 groundwater monitoring wells were installed to form two monitoring well transects. One existing well PT-12A was used as the upgradient well for one of the transects. Groundwater monitoring wells were installed along two transects perpendicular to the biowalls. Wells were installed 15 feet upgradient of the eastern wall, within the footprint of each biowall, between the walls and at distances of 7.5 and 15 feet downgradient (to the west) of the biowalls. These points are used to monitor groundwater geochemical indicators and contaminant concentrations within, between and downgradient of the biowall. **Figure** 3 shows the relative locations of the monitoring wells within the two transects.

4 MONITORING RESULTS

Monitoring results from the four rounds of sampling are presented in the following subsections on hydrogeology, groundwater geochemistry, substrate and electron donor distribution, and degradation of chlorinated ethenes. The results are intended to show that the biowalls have altered groundwater geochemistry to promote reductive dechlorination of chlorinated ethenes. Two transects of monitoring wells are located along the path of groundwater flow, perpendicular to the two biowall trenches (**Figure 3**). The northern flow path (North Transect) consists of wells MWT-12R through MWT-17R. The southern flow path (South Transect) consists of wells PT-12A and MWT-18 through MWT-22. Monitoring points MWT-13, MWT-15, MWT-18 and MWT-20 are located within the biowalls. In addition to these wells, monitoring well MW-39 was sampled between the second and third round on December 1, 2005 to better assess background at the site outside of the plume. Monitoring well PT-22 was also sampled on this date and was added to the last two rounds of sampling to assess affects of the biowall further downgradient of the biowalls (approximately 150 feet downgradient of the biowalls). **Table 1** summarizes the monitoring wells sampled and the dates they were sampled.

Based on the changes in geochemistry observed at these two wells, the biological reaction zone is continuous between the two biowalls and the dual biowalls are intended to operate as a biowall "system." Therefore, groundwater quality exiting the biowall system (i.e., within or immediately downgradient of the west biowall) is the best indicator of the biowall system performance.

4.1 Hydrogeology

Groundwater elevations were measured during each sampling event and are summarized on **Table 2**. It should be noted that the ground was completely saturated during the October 2005 sampling round. **Figure 3** contours the groundwater potentiometric surface for September 1, 2005 (Round 1). Depth to groundwater within the eastern biowall ranged from approximately 2.15 to 6.70 feet bgs. Depth to groundwater within the western biowall ranged from approximately 2.45 to 7.35 feet bgs. The depth of the eastern trench averages 11.3 feet bgs and the depth of the western trench is an average of 10.7 feet bgs. Therefore, the saturated thickness within the two biowall trenches ranges from 3.3 to 9.1 feet at any given time, depending on seasonal changes in groundwater levels due to recharge from precipitation. Seasonal fluctuations of the groundwater table are not expected to adversely impact the biowall performance. Since the biowall is underground and not exposed to the atmosphere, moisture will be retained sustaining the biomass that makes it effective. As described in Section 2, glacial till consists of unsorted silt, clay, sand and gravel to depths of 4 to 15 feet and overlies 2 to 3 feet of weathered shale and competent rock. The biowalls were installed to extend to the top of the competent shale (bedrock) surface. The biowall trenches do not intercept the entire width of the chlorinated ethene groundwater plume as the trenches were installed as a pilot study only. Therefore, mixing of treated groundwater from the biowall and contaminated groundwater downgradient of the biowall trench will occur to some degree. Monitoring results for well locations more than 10 feet downgradient of the biowall should be evaluated with the understanding that not all of the groundwater at those monitoring locations may have passed through the biowall. Results for wells MWT-13, MWT-15, MWT-18 and MWT-20, located within the biowall trenches, are the most representative of the degree to which the biowalls are effective in remediating chlorinated ethenes in groundwater passing through the biowall trenches.

The groundwater surface slopes northwest toward Seneca Lake, with horizontal hydraulic gradients ranging from 0.03 ft/ft to 0.05 ft/ft along the North Transect and ranging from 0.02 ft/ft to 0.03 ft/ft along the South Transect. Rising head slug tests for the wells in the North and South Transects were conducted between October and December 2005, and the results were analyzed to calculate hydraulic conductivity.

Hydraulic conductivity in the till/weathered shale formation ranges from 5.1E-5 to 1.6E-4 cm/sec in the North Transect and ranges from 2.0E-5 to 2.5E-4 cm/sec in the South Transect. The hydraulic conductivities in the biowall were one order of magnitude greater than those in the till/weathered shale formation, ranging from 1.9E-3 to 2.8E-3 cm/sec in the North Transect and ranging from 1.0E-3 to 7.3E-3 cm/sec in the South Transect. This range of hydraulic conductivities falls within the historical range of values calculated for this site during the RI.

Using the calculated hydraulic conductivities derived from the slug test data, the horizontal hydraulic gradients, and an estimated effective porosity of 15 percent, the advective velocities of groundwater flow in the till/weathered shale formation exiting the biowalls were calculated and range from approximately 0.028 to 0.071 ft/day (10 to 26 ft/yr) in the North Transect and range from approximately 0.010 to 0.14 ft/day (4 to 53 ft/yr) in the South Transect. The velocities of groundwater exiting the east biowall along each transect were calculated by considering the hydraulic gradient between the monitoring wells at the western edge of the biowall (MWT-13 and MWT-18) and the monitoring wells immediately downgradient of the east biowall (MWT-14 and MWT-19).

Table 3 shows a comparison of linear velocities derived from the RI slug test data, the biowall-specific 2005 slug test data, and the geochemical parameter monitoring. Observations of geochemical parameters monitored over the duration of the test indicate that linear velocities may be greater than slug test results indicate (see **Attachment A**). Based on the time it took for chemical parameters to be observed at the downgradient wells, it appears that flow through the North Transect may be on the order of 100 ft/yr. Flow through the South Transect may be between 200 and 400 ft/year.

Slug tests measure a hydraulic response to an induced change in groundwater elevation within a single well. This response reflects the conductivity of the entire saturated portion of the well screen interval. Sediments within the screened interval may vary significantly, and the calculated hydraulic conductivity should be considered an "average" for the range of sediments present. Sediments within the glacial till at the Ash Landfill site may consist of clay, silt, or sand. Published values for hydraulic conductivity in glacial tills or for sediments of similar grain size often range over 2 to 3 orders of magnitude or more (**Table 3**). Therefore, groundwater flow along horizons of differing sediment lithologies may also vary by an order of magnitude or more.

The higher velocities of groundwater flow based on observation of geochemical indicator parameters at downgradient monitoring locations are representative of horizons of greater permeability. These higher velocities are about an order of magnitude higher than those derived from slug test results, are well within the range of what may be expected in glacial sediments, and are therefore considered to be conservative estimates of groundwater velocity when considering such factors as residence time. As a conservative measure, future biowall design will be based on maximum rates of groundwater flow, versus an average rate alone.

Based on the highest groundwater velocities calculated above, the most conservative residence time through the biowall system (approximately 18 feet) would be 66 days for the North Transect and between 16 and 33 days for the South Transect. Since these advective velocities are based on the highest velocities observed, they do not account for the effects of a higher effective porosity with the biowall itself and do not account for sorption of contaminants onto soil, these residence times are considered conservative; actual residence times may be higher.

4.2 Groundwater Geochemistry

Biodegradation causes measurable changes in groundwater geochemistry that can be used to evaluate the effectiveness of substrate addition in stimulating biodegradation. For anaerobic reductive dechlorination to be an efficient process, the groundwater typically must be sulfate-reducing or methanogenic. Thus, groundwater in which anaerobic reductive dechlorination is occurring should have the following geochemical signature:

- Depleted concentrations of dissolved oxygen (DO), nitrate, and sulfate;
- Elevated concentrations of ferrous iron, manganese, methane, carbon dioxide, chloride, and alkalinity; and
- Reduced oxidation reduction potential (ORP).

Selected geochemical parameters are shown on **Table 4** (attached). Comparison of geochemical parameters for biowall locations MWT-13 and MWT-18 (East Biowall) and MWT-15 and MWT-20 (West Biowall) to locations outside the biowall are summarized below.

Dissolved Oxygen. Dissolved oxygen is the most favored electron acceptor used by microbes for the biodegradation of organic carbon, and its presence can inhibit the biodegradation of chlorinated ethenes. With the exception of one well between the walls in one round (MWT-19), DO levels are already depleted (less than 2 milligrams per liter [mg/L]) in the study area. In the last round of sampling (January, 2006), concentrations of DO were less than 0.30 mg/L at all sample locations up to 150 feet downgradient of the biowalls.

Oxidation-Reduction Potential. Oxidation-reduction potential (ORP) indicates the level of electron activity and indicates the tendency for the groundwater to accept or transfer electrons. Low ORP, less than -100 millivolts (mV), is typically required for anaerobic reductive dechlorination to occur. Through the first two rounds of sampling, ORP upgradient of the biowall has ranged from 10 to 100 mV, indicating background conditions are only mildly anoxic. Within the east and west biowalls, ORP has been lowered to a range of –137 mV to –220 mV. These levels of ORP indicate conditions are sufficiently reducing within the biowalls to support sulfate reduction, methanogenesis, and anaerobic reductive dechlorination. By January 2006, all monitoring locations downgradient of the biowalls (to a distance of 22.5 feet) are less than -100 mV, indicating that highly reducing conditions are present over a large area downgradient of both biowalls as well. In PT-22, the monitoring location 150 feet downgradient of the biowalls, the ORP changed from 57 mV to -91 mV over the course of the study (between November 2005 and January 2006).

Ferrous Iron. Ferric iron (III) may be used as an electron acceptor during anaerobic biodegradation of organic carbon. During this process, iron (III) is reduced to soluble ferrous iron (II), which can be measured in groundwater samples. An increase in the concentration of iron (II) is an indicator of anaerobic iron reduction. Concentrations of iron (II) upgradient of the biowall are less than 0.41 mg/L. Within the biowall, concentrations of iron (II) are elevated, with a maximum concentration of 5.1 mg/L measured at location MWT-15 in October 2005. Several readings of iron (II) were reported as >3.3 mg/L due to the upper detection limit of the field reagent used. The elevated concentrations are maintained in all downgradient locations. Elevated concentrations were not evident in PT-22, 150 feet downgradient of the biowalls. Iron (II) levels remain close to background at this location.

Sulfate. Sulfate is used as an electron acceptor during sulfate reduction, competing with anaerobic reductive dechlorination for available substrate (electron donor). Sulfate levels lower than 20 mg/L are desired to prevent inhibition of reductive dechlorination of chlorinated ethenes. Sulfate levels upgradient of the biowalls but within the footprint of the plume range from 325 to 903 mg/L. By the second round of sampling, the levels of sulfate were depleted to non-detect levels within the biowalls, except for the January '06 round in MWT-15 (33.2 mg/L). Depletion of sulfate in the North Transect has been more evident than in the South Transect. For example, sulfate levels have decreased in MWT-14 (631 mg/L to 51.9 mg/L), MWT-16 (345 mg/L to 27.8 mg/L), and MWT-17R (408 mg/L to 58.5 mg/L). The levels of sulfate in the wells downgradient along the South Transect have only shown comparable decreases within 7.5 feet downgradient of the biowalls. Levels of sulfate 22.5 feet downgradient of the biowalls in MWT-22 have remained consistent throughout the pilot study (between 278 and 370 mg/L). Further downgradient at PT-22 (150 feet), sulfate levels have decreased slightly from 110 to 78 mg/L between December 2005 and January 2006.

Methane. The presence of methane in groundwater is indicative of strongly reducing methanogenic conditions. An increase in the concentrations of methane is an indication that reducing conditions are optimal for anaerobic reductive dechlorination to occur. Methane concentrations in the two upgradient wells range from 0.001 mg/L to 0.15 mg/L. Concentrations of methane measured in the biowalls were elevated at 3.1 mg/L to 8.1 mg/Lin September 2005, and increased to 14 mg/L to 28 mg/L in January 2006. Methane levels in the downgradient wells (1.0 mg/L to 11 mg/L) are significantly higher than upgradient wells for the October 2005 through January 2006 sampling rounds. In PT-22, 150 feet downgradient of the walls, levels of methane have increased from 0.11 mg/Lin early December 2005 to 0.97 mg/Lin January 2006. Historical data indicates that methane has been non-detect in this well in previous sampling events (2003-2004). There is an increase in the level of methanogenic activity within the biowalls, as well as downgradient over time.

4.3 Substrate Distribution and Electron Donors

The distribution of soluble organic substrate in groundwater is reflected in levels of total organic carbon (TOC) and metabolic acids (**Table 5**) measured in groundwater. The presence of organic substrate is necessary to fuel anaerobic degradation processes, including reductive dechlorination.

Total Organic Carbon. Carbon is an energy source for anaerobic bacteria and drives reductive dechlorination. Generally, during the first three rounds of sampling, TOC concentrations in the wells within the biowalls (86.7 mg/L to 1,990 mg/L) are two orders of magnitude higher than upgradient of the biowalls (2.6 mg/L to 7.3 mg/L). Levels within the biowalls decreased during the third and fourth sampling rounds. For example, levels of TOC decreased from 1,990 mg/Lin MWT-18 to 4.2 mg/L and from 951 mg/L in MWT-20 to 24.8 mg/L. However, levels remain sufficient (>20 mg/L) to maintain sulfate reducing and methanogenic conditions. TOC levels are also much higher in the wells downgradient of the walls ranging from 29.8 mg/L to 35.5 mg/Lin the January 2006 sampling round of wells located 22.5 feet downgradient (MWT-22 and MWT-17R).

Metabolic Acids. Metabolic acids, or volatile fatty acids (VFAs), are produced during the biodegradation of organic substrates (e.g., produced by sulfate reducers). An increase in metabolic acids is an indication that microbial activity has been stimulated. These metabolic acids may be further fermented to produce molecular hydrogen, the primary electron donor utilized during reductive dechlorination of chlorinated ethenes. Metabolic acids (**Table 5**) measured are comprised primarily of acetic, pentanoic, propionic, and butyric acids. Total metabolic acids were less than 1.74 mg/L in the upgradient wells. Total metabolic acid concentrations increased to between 60 mg/L to 7,926 mg/L within the biowalls. In the South Transect downgradient wells, metabolic acid concentrations ranged from 316 to 820 mg/Lin September 2005, and decreased to between 4 and 34 mg/Lin January 2006. In the North Transect, concentrations ranged from 91 to 161 mg/Lin October 2005, and decreased to between 8 to 23 mg/L in January 2006. The decrease in metabolic acid production over time correlates to the decrease in TOC concentrations over time.

In summary, levels of TOC and metabolic acids were highly elevated immediately after installation of the biowall. This is likely due to the rapid dissolution of the soluble portion of organic matter that was present in the mulch and vegetable oil added to the biowall trenches. Levels of TOC and metabolic acids appear to be stabilizing to more sustainable levels. In addition, as the microbial community grows it is capable of utilizing the available organic carbon more rapidly and less organic carbon migrates out of the immediate biowall treatment zone. It is not yet known what levels of substrate the biowall will be able to sustain over the expected design life-cycle of 5 years or more, or what threshold concentrations are required to sustain effective reductive dechlorination. As of January 2006, the effectiveness of the biowall system continues to increase with time (**Section** 4.4) as the microbial community adapts to anaerobic conditions.

4.4 Degradation of Chlorinated Ethenes

Table 6 (attached) summarizes chlorinated ethenes detected in groundwater during the monitoring period of the Ash Landfill biowall pilot study. The first round of groundwater sampling was performed approximately 6 weeks after installation of the biowall. While true "baseline" conditions for the wells located in the trenches and downgradient were not obtained, data from upgradient wells PT-12A and MWT-12R can be used to infer "baseline" conditions immediately upgradient of the biowall.

Trends in Chlorinated Ethene Concentrations

The primary contaminants detected at the site include TCE, cDCE, and vinyl chloride (VC). During the four sampling rounds, upgradient concentrations of TCE ranged from 400 μg/L to 860 μg/L, and upgradient concentrations of cDCE ranged from 310 μg/L to 980 μg/L. Concentrations of VC detected upgradient of the biowall system ranged from <1.2 to 24 μg/L in the South Transect (PT-12A) to 64 to 86 μg/L in the North Transect (MWT-12R). Lower concentrations (less than 25 μg/L) of *trans*-1,2-DCE, 1,1-DCE, 1,1-DCA, and acetone have also been detected in upgradient monitoring locations PT-12A and MWT-12R.

During Rounds 1 and 2, the ratio of TCE to cDCE in the groundwater changed significantly where treatment was occurring. The average cDCE/TCE ratio in the upgradient wells is 1:1 with approximately equal concentrations of TCE and cDCE. Within the two biowalls, the ratio increases to an average of 56:1 where TCE is only detected in one of eight samples. The change in ratio of TCE to DCE is a clear indication that TCE is being degraded to DCE.

As of the second monitoring event in October 2005, a trend of decreasing TCE was observed at all monitoring locations for the biowall network. Concentrations of TCE in the wells within and downgradient of the biowalls continued to decrease even further from September to December 2005, and remained relatively stable from December 2005 to January 2006. In January 2006, concentrations of TCE have decreased to non-detect in the four monitoring wells located within the biowalls and the TCE concentrations in the downgradient monitoring wells have been lowered to concentrations ranging from 2.9 to 25 μg/L. The biowall has significantly reduced the overall toxicity of the groundwater within the biowall treatment zone.

Total Molar Concentrations of Chlorinated Ethenes

The total molar concentration of chlorinated ethenes within the second (western) biowall relative to the upgradient locations are shown in **Table** 7A. The total molar concentrations are calculated by dividing the concentrations of PCE, TCE, DCE and VC by their molecular weight and then summing the results. Percent reductions in total molar concentrations of chloroethenes over time along the northern and southern flow paths have ranged from approximately 86 to 99 percent. A reduction in total molar concentrations shows that the chlorinated ethenes are not simply being converted from one chlorinated ethene to another, and that true reduction to non-toxic degradation products (e.g., ethene) is occurring. Total molar concentrations would be expected to remain constant if TCE was simply being transformed to cDCE without any additional degradation of cDCE. However, total molar concentrations of chloroethenes are clearly depleted within the biowalls. A decrease in total molar concentrations is observed along the North Transect both in the biowall and downgradient of the wall, as shown in **Table 7B**, indicating that a treatment zone has been established in this area. An increase in total molar concentration downgradient of the biowall along the South Transect (as shown in **Table 7B**) may be (i) due to the continued desorption of chlorinated ethenes from downgradient soils or (ii) due to the mixing with untreated groundwater. Less chlorinated compounds are more soluble and less hydrophobic. For example, in the dechlorination sequence of TCE to DCE, solubility goes from 1,100 mg/L for TCE to 3,500 mg/L for cis-DCE (**Table 8**). The organic carbon partition coefficients (K_{oc}), which defines the distribution of chlorinated ethene mass between the sorbed and aqueous phases, also decreases as the level of chlorination decreases. As anaerobic dechlorination proceeds, each successive dechlorination product is more soluble and less susceptible to adsorption than the previous compounds in the sequence. This tendency may result in an increase in aqueous-phase concentrations of less-chlorinated dechlorination products (Payne et al., 2001; Sorenson, 2003).

However, while the transformation of TCE to DCE may result in a temporal accumulation of cDCE in some locations, there remains a significant overall loss of chlorinated ethene mass (greater than 98 percent within the biowalls relative to upgradient locations) as shown in the mass flux calculations provided in **Attachment B**.

Mass Flux and Estimate of Sorbed Mass

An evaluation of contaminant mass flux through the biowall system serves as a measure of system performance in treating contaminant mass. By calculating the mass flux of soluble contaminant that enters the dual biowall system and by comparing that to the mass flux of soluble contaminant exiting the second biowall (western wall), the mass reduction of contamination is demonstrated. **Attachment B** provides the calculations for the mass flux of soluble contaminant entering and exiting each transect of the biowall. The mass flux is calculated using the concentration of each chlorinated ethene multiplied by the volume of water estimated to pass through the trench during a given time period. Based on the calculations in **Attachment B**, the mass reduction of chlorinated ethenes through the dual biowall system is between 98% for the South Transect and over 99% for the North Transect.

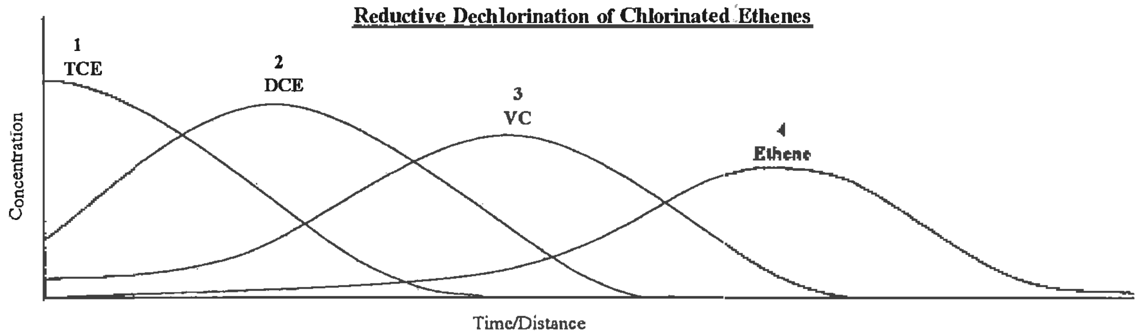
It should also be noted that a reduction in concentrations of TCE downgradient of the biowall would also result in desorption of TCE from the soil matrix. Based on the mass flux calculations shown in **Attachment B**, ten times as much contaminant mass may be sorbed to the soil as is dissolved in the groundwater. It is possible that at least a portion of the rebound in concentrations of cDCE downgradient of the biowall is simply due to desorption of TCE and transformation to cDCE. Similarly, mixing of the highly anaerobic groundwater and untreated groundwater may also cause partial transformation of TCE to cDCE downgradient of the biowall. Because of the affects of desorption and mixing downgradient of the biowall trenches, the concentrations of chlorinated ethenes within the biowall (wells, MWT-15 and MWT-20) are the most meaningful indicators of biowall performance.

Evidence of Sequential Reductive Dechlorination

Observing the relative concentrations of TCE and the by-products generated during reductive dechlorination, progression of the biodegradation process is evident within the Ash Landfill biowall system. The figure below shows the theoretical phased concentrations expected during reductive dechlorination of chlorinated ethenes as outlined in the following steps:

1. TCE is the predominant contaminant source.
2. As TCE is reduced, DCE levels increase.
3. DCE decreases as it is converted to vinyl chloride (VC).
4. Finally, VC is further converted to ethene and other non-toxic by-products.

These four steps are noted on the schematic below.



Figures 4 through 7 show the percent of total chlorinated ethenes (including ethene and ethane) as a function of distance along the biowall transects for Round 2 data and Round 4 data. The four steps outlined above are shown on the figures to indicate the phase of the dechlorination process that dominates. **Figures 4** and **5** show a snapshot of the dechlorination process for the North Transect during Rounds 2 and 4. Reductive dechlorination has proceeded through steps 1 (TCE predominates), 2 (conversion to DCE), and 3 (conversion to VC) during Round 2. In observing the Round 4 data in **Figure 5**, it is clear that the biowall system has matured and that step four (conversion of VC to ethene) is occurring not only within the dual biowall system, but also downgradient of it. A similar trend is seen in **Figures 6** and **7** for the South Transect. The presence of VC downgradient of the biowall system is convincing evidence that treatment zones have begun to be established downgradient of the biowall system. Destruction of contaminants is occurring beyond the installed biowall system.

The production of ethene is a positive indicator of complete dechlorination of the chlorinated ethenes present at the site. If the process resulted in the sole production of VC, ethene levels would not be increasing as measured during the third and fourth sampling rounds. The trends described above can also be shown on a point-by-point basis along both treatment transects. **Attachment C** provides additional graphical analysis of these data at the various locations along both transects.

In observing the fraction of total ethenes over time at certain points within the North and South Transects, it is evident that the reaction zone within the South Transect is effective but is developing at a slower rate than in the North Transect. **Figures 8** through **11** show the fraction of total ethenes over time for monitoring wells MWT-13, MWT-16, MWT-18 and MWT-21. When comparing the fraction of total ethenes in the wells within the first wall (MWT-13 and MWT-18) and in the first downgradient wells (MWT-16 and MWT-21), the observed phase of reductive dechlorination is approximately 40 to 50 days behind in the South Transect. In other words, the progress seen at 190 days in the South Transect was observed at about 140 days in the North Transect.

4.5 Other Compounds

The tables presented in **Attachment D** list all of the detected VOC compounds in all biowall performance monitoring wells. **Table** 6 shows concentrations of acetone, 2-butanone and 2-hexanone in addition to chlorinated compounds of concern. Ketones have been detected in the monitoring wells located within the biowalls at concentrations up to 9,300 μg/L for 2-butanone at location MWT-13 in October 2005. These compounds, produced by fermentation reactions, are not anticipated to be stable outside of the highly reducing conditions established within and immediately downgradient of the biowall trenches. They readily degrade in aerobic conditions and decrease as the levels of TOC and metabolic acids decrease. Concentrations of these compounds decreased by over an order of magnitude (to 750 μg/L or less) in downgradient locations at 7.5 feet from the west biowall. Furthermore, concentrations of these compounds were between non-detect and 14 J μg/L at 22.5 feet downgradient of the biowalls in January, and concentrations were non-detect at the furthest downgradient well (PT-22, 150 feet from the biowalls) monitored in January 2006. Over the five month study, these ketones have decreased in locations downgradient of the biowall as shown in **Figures 12 through 15**. They have never been detected in PT-22, 150 feet downgradient of the biowall system. Therefore, it is not anticipated that these compounds will adversely impact groundwater quality outside of the immediate biowall treatment zone.

5 PERFORMANCE ANALYSIS

5.1 Objectives of the Biowall Pilot Test

The Ash Landfill Biowall Pilot Test Work Plan (Parsons, May 2005) outlined five performance objectives that were developed to evaluate the effectiveness of the biowalls. The evaluation of these five objectives is the basis of mulch as the media selected for the reactive walls for the groundwater operable unit as required in the Record of Decision for this site (January, 2005).

The objectives outlined in the Biowall Pilot Study Work Plan and the assessment of this objective using the data collected to date discussed below:

Objective	Assessment to Date
1. Achieve similar reduction of concentrations ofTCE within each biowall as was demonstrated for the ZVI PRB.	As shown in **Table 7A**, TCE concentration reduction is greater than 99% when comparing the upgradient wells to the wells within the West Biowall. As shown in **Table 9A**, TCE concentration reduction was between 75-99.9% in the ZVI PRB,(comparing the upgradient well to the well within the wall). Overall, the TCE reduction is better consistently in the biowalls.
2. Demonstrate a reduction in total molar chlorinated ethene concentrations in the biowalls and at monitoring locations downgradient of the biowalls that is equal to or greater than that achieved in the ZVI PRB.	As shown in **Table 7A**, the total molar chlorinated ethene reduction is between 86 and 99% when comparing the upgradient wells to the wells within the West Biowall. As shown in **Table 9B**, the total molar chlorinated ethene reduction in the ZVI PRB (comparing the upgradient well to the well within the wall) was between 35-99.4%. Overall, results are better within the biowall.

Objective	Assessment to Date
3. Demonstrate that the biowalls create a treatment zone within and downgradient of the trenches that is favorable to the long-term enhancement of degradation of TCE and its regulated intermediate degradation products.	Zones have already been created within and downgradient of the biowalls. Geochemical data shown in **Table 10** and discussed in this section indicate the presence of these zones. Good chlorinated ethene destruction already observed downgradient of the system in the North Transect as shown in **Table 7B**. Degradation of chlorinated ethenes is occurring in the South Transect at a somewhat slower rate, however, geochemical parameters and trends indicate increased degradation will occur as well.
4. Demonstrate that no chlorinated solvents will exceed NYSDEC GA Standards at the Farm House west of the site at any time during the estimated remediation timeframe.	Sampling of monitoring well MW-56 located upgradient of the Farm House was conducted in Round 2. The results showed no contaminant concentrations exceeding the Class GA groundwater standards. Historic sampling has shown that the wells further downgradient at the farm house are not impacted by chlorinated ethenes. ROD-required monitoring and contingency plan will assure that this Farm House remains unaffected.
5. Evaluate biowall design criteria (e.g., organic carbon generation, degradation rates, residence time) and constructability issues (e.g. trenching techniques, trench stability, oil application, and subsurface pipe placement) required for effective long-term operation.	Sufficient data has been collected during the biowall pilot study to evaluate design parameters in the Remedial Design Report. The location and number of walls, dimensions of the walls, and application of oil will be fully evaluated in this report.

5.2 Discussion of Objectives

As shown in the table above, assessment of the objectives indicates that the use of mulch as the reactive media within the walls is satisfactory.

Objective 1: Achieve similar reduction of concentrations of TCE within each individual biowall as was demonstrated for the ZVI PRB described in the Feasibility Memorandum (Parsons, 2000).

Assessment of Objective 1: As shown in **Table 7A**, TCE concentration reduction is greater than 99% when comparing the upgradient wells to the wells within the West Biowall. Reduction in the North Transect has been slightly greater than reduction in the South Transect, although reduction in the South Transect improved during the last sampling round (from 96 to 99%) for the East Biowall. Faster flow rates through the South Transect may be responsible for the lag in reduction efficiency, but results show that this will improve over time.

As shown in **Table 9A**, TCE concentration reduction was between 75-99.9% in the ZVI PRB. Data from the treatability study for the ZVI wall were used in this assessment (1999/2000).

Overall, reduction of TCE concentrations is similar if not better in the biowall.

Objective 2: Demonstrate a reduction in total molar concentrations of chlorinated ethenes in the biowalls and at monitoring locations downgradient of the biowalls. Total molar chlorinated ethene concentrations were calculated and used to assess the treatment efficiency of the biowalls. Concentrations of chlorinated ethenes plus vinyl chloride were converted to their molar equivalents and added together. Total molar chlorinated ethene concentrations at upgradient monitoring wells were compared with those observed in the West Biowall and at downgradient monitoring wells. Results from this biowall pilot study were compared to the molar reduction results that were calculated from concentration measurements performed over time from monitoring wells in and around the ZVI PRB.

Assessment of Objective 2: As shown in **Table 7A**, the total molar chlorinated ethene reduction is between 86 and 99% when comparing the upgradient wells MWT-12R and PT-12A to the wells in the West Biowall (MWT-15 and MWT-20). During the last round of sampling, between 97 and 99% reduction in chlorinated ethenes was observed in both transects. As shown in **Table 9A**, the total molar chlorinated ethene reduction in the ZVI PRB was between 35-99.4%. Reduction is equal to if not greater in the biowalls than the ZVI PRB.

Downgradient of the biowalls, the reduction of total molar chlorinated ethenes varies as shown in **Table 7B**. In the North Transect, reduction immediately downgradient in MWT-16 and further downgradient in MWT-17R ranged from 83 to 92% during the last round of sampling. In the South Transect, the percent reduction does not yet reflect what is occurring within the Western biowall. During the last sampling round, the percent reduction of chlorinated ethenes was between 5 and 18%. As explained in **Section 4.4**, an increase in total molar concentration downgradient of the biowall within the South Transect may be (i) due to the continued desorption of chlorinated ethenes from downgradient soils, or (ii) due to the mixing with untreated groundwater. Less chlorinated compounds are more soluble and less hydrophobic. For example, in the dechlorination sequence of TCE to DCE, solubility goes from 1,100 mg/L for TCE to 3,500 mg/L for cis-DCE (**Table 8**). The organic carbon partition coefficients (K_{oc}), which defines the distribution of chlorinated ethene mass between the sorbed and aqueous phases, also decreases as the level of chlorination decreases. As anaerobic dechlorination proceeds, each successive dechlorination product is more soluble and less susceptible to adsorption than the previous compounds in the sequence. This tendency may result in an increase in aqueous-phase concentrations of chlorinated compounds having fewer chlorine atoms (Payne et al., 2001; Sorenson, 2003).

However, while the transformation of TCE to DCE may result in a temporal accumulation of cDCE in some locations, there remains a significant overall loss of chlorinated ethene mass (greater than 98 percent within the biowalls relative to upgradient locations) as shown in the mass flux calculations provided in **Attachment B**.

Based on the data collected during the ZVI wall pilot study (1999/2000), total molar chlorinated ethene reduction downgradient of the ZVI wall ranged from 41 to 91% (2.5 feet from the biowall). Using the most recent rounds of monitoring results at the ZVI wall (2004), total molar chlorinated ethene reduction ranged from -19 to 79 %. During this round, an increase in total molar chlorinated ethenes was observed in the southern transect of the ZVI wall. This may have been due to desorption of chlorinated ethenes from the soil matrix downgradient of the ZVI wall. These results are shown in **Table 9B**.

One difference between the ZVI wall and the biowall system is the size of the treatment zone. The ZVI wall relies on contact between chlorinated ethenes within the groundwater and an iron matrix of a fixed width. The treatment zone, therefore, is limited to the width of the trench containing the ZVI matrix. In the biowall system, the treatment zone extends beyond the installed width of the biowall. As the TOC migrates out of the installed biowall, a treatment zone is established beyond the wall width. In addition, desorption of the chlorinated ethene mass is enhanced. This increases the effectiveness of the biowall by enhancing the mass transfer of chlorinated ethenes to the aqueous phase, where they are subject to biodegradation processes. The physical and chemical properties of chlorinated ethenes affect many of these processes, and a summary of their properties are listed on **Table 8**. Enhanced dissolution or desorption occurs from several processes, including creating more soluble dechlorination compounds and affecting interfacial tension. More chlorinated ethenes go into solution downgradient of the biowall and treatment of these newly dissolved chlorinated ethenes continues to occur due to the extension of the treatment zone.

Objective 3: Demonstrate that the biowalls create a treatment zone within and downgradient of the trenches that is favorable to the long-term enhancement of degradation of TCE and its regulated intermediate degradation products, *cis*-1,2-DCE and *trans*-1,2-DCE and VC.

***Assessment of Objective 3*:** Parameters indicative of chlorinated compound reduction were reviewed. Levels indicate that zones within and downgradient of the biowalls have been established. Depressed oxygen, nitrate, and sulfate levels indicate that these electron receptors are being exhausted making chlorinated compounds a more favorable electron receptor (leading to its eventual destruction) (EPA, 1998). Increases in carbon dioxide, methane, volatile fatty acids, alkalinity and chlorides indicate that enhanced reductive dechlorination processes are occurring (EPA, 1998).

Figures 4 through **7** show the changes in the fraction of total ethenes from the upgradient wells (MWT-12R and PT-12A) to the most downgradient wells (MW-17R and MWT-22) for Round 2 data and Round 4 data in the North and South Transects. The four sequential dechlorination steps outlined in **Section 4** are shown on the figures to indicate the phase of the dechlorination process that dominates. **Figures 4** and **6** show a snapshot of the dechlorination process for the North and South Transects during Round 2. Reductive dechlorination has proceeded through steps 1 (TCE predominates), 2 (conversion to DCE), and 3 (conversion to VC). In observing the Round 4 data (**Figures 5** and **7**), it is clear that the biowall system has matured and that step four (conversion of VC) is occurring within the biowall system as well as downgradient of the system. The production of ethene is a very positive indicator of complete dechlorination of the chlorinated ethenes present at the site. Ethene and ethane are not only being produced within the biowall system but also in the wells downgradient of the system. If the process resulted in the sole production of VC, ethene levels would not be increasing as they are during the third and fourth sampling rounds. An adequate reaction zone has been established to degrade DCE and VC and this zone extends beyond the biowall system itself.

Objective 4: Demonstrate that no chlorinated solvents will exceed NYSDEC GA Standards at the Farm House west of the site at any time during the estimated remediation timeframe.

Assessment of Objective 4: Sampling conducted in Round 2 included MW-56 located upgradient of the Farm House (1,250 feet upgradient). This well remains unaffected by chlorinated solvents and therefore downgradient wells may be considered unaffected. ROD-required monitoring and contingency plan requirements will assure that down gradient receptors remain unaffected.

Objective 5: Evaluate biowall design criteria (e.g., organic carbon generation, degradation rates, residence time) and constructability issues (e.g. trenching techniques, trench stability, oil application, and subsurface pipe placement) required for effective long-term operation.

Assessment of Objective 5: Based on the results of the biowall study, the following design criteria will be assessed in the Remedial Design Report for this project:

- Trench constructability;
- The number, dimensions and location of the Biowalls to provide adequate coverage of the plume and adequate retention time to meet remedial action objectives.
- Production of other by-products, (e.g. ketones) and any adverse effects downgradient.
- The use and frequency of application of vegetable oil in the process.

Sufficient data has been collected during the pilot study to make a reasonable assessment of the above parameters for the purposes of full scale design.

6 SUMMARY AND PATH FORWARD

Based on the results of the Ash Landfill Biowall Pilot Study, the following conclusions are summarized below:

- TCE concentration reduction between the upgradient wells and the wells within the second biowall (West Biowall) is greater than 99%.

- The total molar chlorinated ethene reduction between the upgradient wells and the wells within the second biowall (West Biowall) is between 86 and 99%.

- Geochemical data and chlorinated ethene reduction indicates that treatment zones have already been established within and downgradient of the dual biowall system. Development of this treatment zone within the South Transect, although present, is lagging the development in the North Transect by about 40 to 50 days.

- The molar fraction of ethene is increasing within and downgradient of the biowall system and is a positive indicator of complete dechlorination of the chlorinated ethenes present at the site. If the process resulted in the sole production of VC, ethene levels would not be increasing as measured during the third and fourth sampling rounds. The presence of VC downgradient of the biowall system is solid evidence that treatment zones have begun to be established downgradient of the biowall system. Destruction of contaminants is occurring beyond the installed treatment system.

- Based on mass flux calculations (**Attachment B**), ten times as much contaminant mass may be sorbed to the soil as is dissolved in the groundwater. It is possible that at least a portion of the rebound in concentrations of cDCE downgradient of the biowall is simply due to desorption of TCE and transformation to cDCE.

- Observations of geochemical parameters monitored over the duration of the test indicate that advective velocities may be greater than slug test results indicate. Based on the time it took for chemical parameters to be observed at the downgradient wells, it appears that flow through the North Transect may be on the order of 100 ft/yr. Flow through the South Transect may be between 200 and 400 ft/year. Based on these velocities, the residence time through the biowall system (approximately 18 feet) would be 66 days for the North Transect and between 16 and 33 days for the South Transect.

- Sampling of monitoring well MW-56 located upgradient of the Farm House was conducted in Round 2. The results showed no contaminant concentrations exceeding the Class GA groundwater standards.

- Certain ketones are being produced as a result of fermentation reactions within the biowalls. These readily degrade in aerobic conditions and the magnitude of the concentrations of acetone, 2-butanone and 2-hexanone within the biowall anaerobic reaction zone are decreasing as the levels of TOC and metabolic acids decrease. These ketones have not been detected in the groundwater 150 feet downgradient of the biowalls. Therefore, it is not anticipated that these compounds will adversely impact groundwater quality outside of the immediate biowall treatment zone.

- Sufficient design information has been acquired during the pilot study to proceed with full-scale design.

The five objectives of the biowall pilot study have been met as outlined in **Section 5**. The biowall performance has been shown to be comparable, if not superior to that of the ZVI wall. In light of this information, the Army recommends that full-scale design of a biowall groundwater treatment system for the Ash Landfill commence.

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TABLES

Table 1
Summary of Monitoring Wells and Sampling Dates
ASH LANDFILL MULCH BIOWALL
SENECA ARMY DEPOT, ROMULUS, NEW YORK

Round	**Round 1**	**Round 2**		**Round 3**	**Round 4**
Date	Sept. 7-12, 2005	Oct. 24-26, 2005	Dec. 1, 2005	Dec. 12-16, 2005	Jan. 24-28, 2006
North Transect					
MWT-12R	X	X		X	X
MWT-13	X	X		X	X
MWT-14	X	X		X	X
MWT-15	X	X		X	X
MWT-16	X	X		X	X
MWT-17	X	X		X	X
South Transect					
PT-12A	X	X		X	X
MWT-18	X	X		X	X
MWT-19	X	X		X	X
MWT-20	X	X		X	X
MWT-21	X	X		X	X
MWT-22	X	X		X	X
Upgradient Outside of Plume (1)					
MW-39			X	X	
150 feet Downgradient of Biowall (2)					
PT-22			X	X	X

(1) MW-39, a well upgradient of the plume, was sampled to obtain background geochemical parameters for the site outside of the plume. These were needed for comparison purposes at the site and were not originally outlined in the pilot study work plan (Parsons, 2005).

(2) Because the wells furthest downgradient in the pilot study transects (MWT-17R and MWT-22) were showing signs that enhanced biodegradation was beginning to occur after the Round 2, PT-22 (a well further downgradient) was sampled to assess effects further downgradient. This well was not part of the monitoring plan as outlined in the pilot study work plan (Parsons, 2005).

TABLE2
SUMMARY OF GROUNDWATER ELEVATIONS
ASH LANDFILL MULCH BIOWALL
SENECA ARMY DEPOT, ROMULUS, NEW YORK

Well/Borehole Identification	Date	Screened Interval (feet bgs)[a]	Ground Surface (feet amsl)[b]	Elevation Datum (toe) (feet amsl)	Depth to Water (feet btoc)[c]	Groundwater Elevation (feet amsl)
Northern Flow Path						
MWT-12R	7-Sep-05	3.9 - 8.9	649.0	651.09	6.80	644.29
	24-Oct-05				2.45	648.64
	12-Dec-05				3.91	647.18
	26-Jan-06				2.80	648.29
MWT-13	7-Sep-05	4.65 - 9.65	648.5	650.83	6.70	644.13
	24-Oct-05				2.15	648.68
	12-Dec-05				3.80	647.03
	26-Jan-06				2.70	648.13
MWT-14	7-Sep-05	4.8 - 9.8	648.8	650.93	7.00	643.93
	24-Oct-05				2.60	648.33
	12-Dec-05				4.25	646.68
	26-Jan-06				3.15	647.78
MWT-15	7-Sep-05	5.25 - 10.25	648.9	651.13	7.35	643.78
	24-Oct-05				2.90	648.23
	12-Dec-05				4.74	646.39
	26-Jan-06				3.55	647.58
MWT-16	7-Sep-05	4.8 - 9.8	648.4	650.61	7.10	643.51
	24-Oct-05				2.75	647.86
	12-Dec-05				4.68	645.93
	26-Jan-06				3.50	647.11
MWT-17R	7-Sep-05	5.4 - 10.4	648.1	650.28	6.95	643.33
	24-Oct-05				2.80	647.48
	12-Dec-05				4.75	645.53
	26-Jan-06				3.55	646.73

TABLE2
SUMMARY OF GROUNDWATER ELEVATIONS
ASH LANDFILL MULCH BIOWALL
SENECA ARMY DEPOT, ROMULUS, NEW YORK

Well/Borehole Identification	Date	Screened Interval (feet bgs)[a/]	Ground Surface (feet amsl)[b/]	Elevation Datum (toe) (feet amsl)	Depth to Water (feet btoc)[c/]	Groundwater Elevation (feet amsl)
			(continued)			
Southern Flow Path						
PT-12A	7-Sep-05	4.8 - 9.8	648.7	651.13	6.80	644.33
	24-Oct-05				2.65	648.48
	12-Dec-05				4.12	647.01
	26-Jan-06				3.05	648.08
MWT-18	7-Sep-05	5.4 - 10.4	648.5	650.72	6.45	644.27
	24-Oct-05				2.20	648.52
	12-Dec-05				4.02	646.70
	26-Jan-06				2.75	647.97
MWT-19	7-Sep-05	4.0 - 9.0	648.5	650.65	6.45	644.20
	24-Oct-05				2.40	648.25
	12-Dec-05				4.16	646.49
	26-Jan-06				3.00	647.65
MWT-20	7-Sep-05	5.05 - 10.05	648.8	650.67	6.65	644.02
	24-Oct-05				2.45	648.22
	12-Dec-05				4.25	646.42
	26-Jan-06				3.10	647.57
MWT-21	7-Sep-05	4.35 - 9.35	648.3	650.58	6.70	643.88
	24-Oct-05				2.50	648.08
	12-Dec-05				4.35	646.23
	26-Jan-06				3.10	647.48
MWT-22	7-Sep-05	7.45 - 12.45	648.2	650.66	7.15	643.51
	24-Oct-05				2.53	648.13
	12-Dec-05				5.25	645.41
	26-Jan-06				3.85	646.81

toe = top of casing

a/ feet bgs indicates feet below ground surface.

b/ feet amsl indicates elevation in feet above mean sea level.

c/ feet btoc indicates depth in feet below top of casing.

d/ NM indicates datum not measured.

Table 3
Range of Hydraulic Conductivities and Linear Velocities for the Ash Landfill
Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

	RI Slug Test Data[1]	2005 Slug Test Data[2]	Geochemical Parameters[3]	Published Values[4]			
				Till	Fine Sand	Silt	Clay
Range of Hydraulic Conductivity, k (cm/sec)	3.9×10^{-5} - 5.3×10^{-4}	2.0×10^{-5} - 2.5×10^{-4}	NA	10^{-10} - 2×10^{-4}	2×10^{-5} - 2×10^{-2}	1×10^{-7} - 2×10^{-3}	1×10^{-9} - 4.7×10^{-7}
Porosity	15%	15%	NA	NA	NA	NA	NA
Gradient (ft/ft)	0.020	0.019-0.049	NA	NA	NA	NA	NA
Linear velocity (ft/year)	45.5 - 60.7	4 - 52	100 - 400	NA	NA	NA	NA

Notes:
1. Values derived from slug testing data of 8 wells from Remedial Investigation (1991)
2. Values derived from slug testing data of wells surrounding biowall based on slug testing data
3. The linear velocity was based on the time it took for certain geochemical parameters to travel a specified distance; the value was not calculated based on a hydraulic conductivity.
4. Domenico, P .A., and F. W. Schwartz. 1990. Physical and Chemical Hydrogeology. John Wiley and Sons. New York, NY.

NA - Not applicable

TABLE 4
GROUNDWATER GEOCHEMICAL DATA
ASH LANDFILL MULCH BIOWALL
SENECA ARMY DEPOT, ROMULUS, NEW YORK

Sample Location		Dissolved Oxygen (mg/L)	pH (SU)	Oxidation Reduction Potential (mV)	Turbidity (NTU)	Specific Conductance (mS/cm)	Temperature $^{\circ}C$	Manganese (mg/L)	Sulfide (mg/L)	Ferrous Iron (mg/L)	Carbon Dioxide (mg/L)	Alkalinity (mg/L)	Chloride (mg/L)	Nitrate (mg/L-N)	Nitrite (mg/L-N)	Sulfate (mg/L)	Total Organic Carbon (mg/L)	Methane (ug/L)	Ethane (ug/L)	Ethene (ug/L)
MW-39	02-Dec-05	0.31	7.19	76	19.4	0.68	10.7	0	0.05	0.11	400	212	2.8	<0.05	<0.05	27.2	<1.0	0.79	0.006 J	<0.025
(Background)	16-Dec-05	0.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PT-22	02-Dec-05	1.0	6.98	57	-2.6	0.812	9.85	1.4	0.02	4	1030	413	19.4	<0.05	<0.05	110	7.8	110	0.017J	10
(150' Downgrad of	16-Dec-05	0.08	7	-44	8.2	1.34	10.15	0.8	0.01	0.1	981	649	26.6	<0.05	<0.05	88.8	13.4	990	0.14	45
the walls)	24-Jan-06	0.1	7.28	-91	0.2	0.922	7	1.5	0.01	0.17	380	472	16.9	NA	NA	78.3	6.9	970	0.3	30
South Transect																				
PT-12A	07-Sep-05	0.96	7.14	50	0	1.04	18.5	0.3	0	0.04	0.24	313	44.2	0.98	<0.05	325	4.7	1.1	0.1	0.066
(15' Upgradient)	24-Oct-05	0	6.88	32	60	1.36	13.1	0.5	0	0.17	222	420	38	0.98	<0.05	390	4	11.0	0.17	0.18
	12-Dec-05	0.41	7.03	84	7.6	1.38	9.66	0.3	0.01	0.3	152	306	49	<0.05	<0.05	515	2.6	15.0	0.15	0.2
	24-Jan-06	0.39	7.25	93	0.3	1.51	7	1.1	0	0.16	380	320	40.3	NA	NA	585	4.2	26	0.18	0.25
MWT-18	07-Sep-05	1.25	6.57	-178	90.1	4.3	22.9	22*	15.4	4.7	100	2630	128	<0.05	<0.05	71.7	1990	4600	0.52	0.55
(in western wall)	24-Oct-05	0	6.44	-177	102	2.89	16.1	22*	0.19	2.51	980	1700	4.2	<0.05	<0.05	<2.0	777	14000	0.054	0.084
	12-Dec-05	0.1	6.62	-137	116.3	3.56	10.8	22*	0.15	2.49	998	1420	73.4	<0.05	<0.05	<10	918	11000	0.039	0.72
	24-Jan-06	0.06	6.62	-151	76	3.51	8.2	22*	0.26	3.11	1000*	1430	105	NA	NA	<4.0	4.2	19000	0.29	2.7
MWT-19	07-Sep-05	2.19	7.74	-145	0	2.3	22	12.4	0.05	5.1	76.2	846	92.8	<0.05	<0.05	492	208	98	0.18	0.46
(between walls)	24-Oct-05	0	6.79	-226	134	1.79	14.31	5.6	0.04	3.30*	602	940	70.7	<0.05	<0.05	150	42.4	1100	0.29	0.67
	12-Dec-05	0.74	7	-114	9.1	2.12	7.99	3	0.03	2.04	764	999	85.9	<0.05	<0.05	148	48	2100	0.37	7.5
	24-Jan-06	0.06	6.91	-256	30.3	2.11	7.6	7.4	0.07	3.30*	1000*	1145	83.8	NA	NA	80.3	74.05	3850	0.55	115
MWT-20	07-Sep-05	0.12	7.7	-197	80	3.38	22.2	13.2	0.54	2.73	48	2480	73.4	<0.05	<0.05	<2.0	951	7700	0.04	0.22
(in eastern wall)	24-Oct-05	1.07	7.22	-212	127	3.09	17.04	11.9	0.3	3.30*	434	2350	31.3	<0.05	<0.05	<2.0	268	13000	0.01J	0.54
	12-Dec-05	0.07	6.76	-149	389	2.77	10.18	22*	0.14	2.47	938	917	47.2	<0.05	<0.05	<4.0	173	12000	0.042	11
	24-Jan-06	0.07	6.76	-171	53.2	2.48	7	22*	0.11	3.3*	986	995	31.2	NA	NA	<4.0	24.8	18000	0.35	16
MWT-21	07-Sep-05	0.44	7.85	-245	9.1	2.17	19.8	15.8	0.632	4.1	19	118	85.2	<0.05	<0.05	443	165	1000	0.45	0.78
(7.5' downgradient)	24-Oct-05	1.22	7.19	-275	29.5	2.17	15.41	9.4	0.11	3.30*	410	1090	54.6	<0.05	<0.05	156	113	3300	0.26	1.7
	12-Dec-05	0.04	6.8	-235	40.2	2.37	9.3	0.6	-	2.06	936	1500	59.8	<0.05	<0.05	199	70.1	6100	0.38	83
	24-Jan-06	0.1	8.02	-273	34	2.16	7.3	10.9	0.28	2.41	920	940	37.3	NA	NA	114	53.5	11,000	0.85	100
MWT-22	07-Sep-05	0.45	8.1	-180	32.2	2.31	17.8	22	0.269	4.73	15	1030	154	<0.05	<0.05	278	361	1300	1.7	3.4
(22.5' downgradient)	24-Oct-05	1.28	7.35	-228	30	2.07	13.6	6.1	0.04	2.68	484	1115	110	<0.05	<0.05	296	33.2	1900	1.2	3.5
	12-Dec-05	0.04	6.82	-206	20	2.15	9	0.7	0.06	2.27	996	861	78.6	<0.05	<0.05	282	34.5	1900	1.2	95
	24-Jan-06	0.15	6.72	-104	60	2.03	8.3	6.1	0.05	2.3	722	731	63.5	NA	NA	370	35.5	2300	1.2	93

TABLE 4
GROUNDWATER GEOCHEMICAL DATA
ASH LANDFILL MULCH BIOWALL
SENECA ARMY DEPOT, ROMULUS, NEW YORK

Sample Location		Dissolved Oxygen (mg/L)	pH (SU)	Oxidation Reduction Potential (mV)	Turbidity (NTU)	Specific Conductance (mS/cm)	Temperature °C	Manganese (mg/L)	Sulfide (mg/L)	Ferrous Iron (mg/L)	Carbon Dioxide (mg/L)	Alkalinity (mg/L)	Chloride (mg/L)	Nitrate (mg/L-N)	Nitrite (mg/L-N)	Sulfate (mg/L)	Total Organic Carbon (mg/L)	Methane (ug/L)	Ethane (ug/L)	Ethene (ug/L)
North Transect																				
MWT-12R	07-Sep-05	1.67	7.32	10	0	1.54	22.1	1	0.01	0.41	19	304	108.1	0.11	<0.05	732	7.3	23	0.35	1.52
(15' Upgradient)	24-Oct-05	0	6.86	27	1	2.08	13.65	0.8	0.01	0.05	340	800	120	<0.05	<0.05	767	4.9	97	0.63	2.25
	12-Dec-05	0.84	6.92	36	16.1	1.94	8.43	1	0.1	0.22	<500	301	116	<0.05	<0.05	903	3.7	140	1.3	3.6
	24-Jan-06	0.56	6.95	54	0.73	2.09	7.4	1	0.03	0	656	296	169	NA	NA	741	3.8	150	0.85	2.7
MWT-13	07-Sep-05	0	6.01	-220	90	6.44	20.5	22*	0.61	0.01	115	183	199	<0.05	<0.05	<20	296	3100	0.5	0.93
(in western wall)	24-Oct-05	0	6.47	-158	85.5	4.38	15.38	22	0.24	2.81	1000	2530	13.2	<0.05	<0.05	<2.0	1310	10000	0.11	0.15
	12-Dec-05	0.06	6.55	-169	492	3.16	10.55	22*	0.2	3.15	3370	10 U	66	<0.05	<0.05	<4.0	588	12000	<0.025	0.8
	24-Jan-06	0.11	6.54	-150	47.5	3.29	7.4	22*	0.19	3.30*	1000*	731	97.4	NA	NA	<4.0	298	14000	0.078	6.8
MWT-14	07-Sep-05	0	6.72	-177	0	2.96	21.1	22*	0.1	0.04	19.2	1240	139	<0.05	<0.05	631	610	31	0.15	0.26
(between walls)	24-Oct-05	1.08	7.19	-252	39.1	2.66	14.83	22*	0.11	3.30*	1000	1450	65.9	<0.05	<0.05	69.9	432	6100	0.1	0.34
	12-Dec-05	0.17	6.3	-165	342	2.43	11.5	22*	0.13	3.30*	2750	1170	77.6	<0.05	<0.05	53.8	275	14000	0.22	89
	24-Jan-06	0.15	6.59	-113	220	2.61	6.7	22*	0.18	2.7	1000*	879	61.3	NA	NA	51.9	209	14000	2.4	190
MWT-15	07-Sep-05	0	6.9	-199	63	3.88	20.6	22*	0.31	5.1	57	2020	106	<0.05	<0.05	<4.0	1060	8100	0.031	0.28
(in eastern wall)	24-Oct-05	1.05	7.27	-206	53.1	3.21	16.48	17.6	0.16	2.81	960	1900	6.5	<0.05	<0.05	<2.0	267	10000	<0.008	1.9
	12-Dec-05	0.06	6.28	-159	266	1.87	11.08	22*	0.14	2.61	-	774	31	<0.05	<0.05	<10.0	86.7	17000	0.99	16
	24-Jan-06	0.16	6.76	-150	200	1.56	6.5	22*	0.09	2.44	1000*	515	22.1	NA	NA	33.2	46.6	28000	4.3	15
MWT-16	07-Sep-05	1.7	7.1	-119	0	1.55	20.4	1	0.3	0.83	16	551	75.4	0.76	<0.05	345	63.5	23	0.081	0.14
(7.5' downgradient)	24-Oct-05	1.35	7.13	-175	52.2	2.28	14.4	7.3	0.13	2.24	1018	1300	6.7	<0.05	<0.05	2	204	4800	0.19	2.2
	12-Dec-05	0	6.45	-160	61.2	1.94	10.69	22*	0.14	3.30*	1082	1050	57	<0.05	<0.05	16.9	88.6	6200	0.68	72
	24-Jan-06	0.18	6.65	-128	37	2.1	7.9	22*	0.02	2.58	966	929	38.7	NA	NA	27.8	51.7	11000	5.3	120
MWT-17R	07-Sep-05	1.25	7.28	60	0	1.3	20.7	0.1	0.7	0	25	351	62.8	0.84	<0.05	408	9.3	1.1	0.085	0.21
(22.5' downgradient)	24-Oct-05	0	6.75	-27	25.5	1.8	13.8	5.2	.0.1	0.2	544	1005	37.8	0.34	<0.05	80.5	111	1000	0.049	0.58
	12-Dec-05	0	6.39	-126	93.9	1.72	8.7	3.3	0.08	0.8	820	1180	37.8	<0.05	<0.05	43.8	63.8	4700	0.38	42
	24-Jan-06	0.29	7.56	-156	22.4	1.64	6.7	15.2	0.07	3.30*	960	781	23.7	NA	NA	58.5	29.8	7300	1.4	51

* Over the limit of the test reagent
- Parameter could not be measured

TABLE 5
VOLATILE FATTY ACIDS IN GROUNDWATER
ASH LANDFILL MULCH BIOWALL
SENECA ARMY DEPOT, ROMULUS, NEW YORK

Sample Location		Acetic Acid (mg/L)	Butyric Acid (mg/L)	Hexanoic Acid (mg/L)	Pentanoic Acid (mg/L)	Propionic Acid (mg/L)	Pyruvic Acid (mg/L)	Total VFAs (mg/L)	Total Organic Carbon (mg/L)
South Transect									
PT-12A	07-Sep-05	0.129	<0.07	<0.1	<0.07	<0.07	<0.07	0.129	4.7
(15' Upgradient)	24-Oct-05	0.177	<0.07	<0.07	<0.07	<0.07	<0.07	0.177	4
	12-Dec-05	0.068	<0.07	<0.1	<0.07	<0.07	<0.07	0.068	2.6
	24-Jan-06	0.048	<0.07	<0.1	<0.07	<0.07	<0.07	0.048	4.2
MWT-18	07-Sep-05	1820	296	62	244	1190	<70	3612	1990
(in western wall)	24-Oct-05	66.2	27.5	NA	81.5	794	<0.07	969	777
	12-Dec-05	99.1	16.4	<10	13.7	1030	<7	1159.2	918
	24-Jan-06	483	18.5	1.28	14.2	497	<0.7	1014	726
MWT-19	07-Sep-05	148	25.8	<10	21.7	204	<7	399.5	208
(between walls)	24-Oct-05	40.6	1.63	NA	1.92	71.5	<0.07	115.6	42.4
	12-Dec-05	15.7	0.94	<0.1	0.348	32.2	<0.07	49.2	48
	24-Jan-06	52.9	0.9	<0.1	0.4	28.1	<0.7	82.3	74.1
MWT-20	07-Sep-05	76.5	21.8	<10	36.4	313	<7	447.7	951
(in eastern wall)	24-Oct-05	51.1	1.16	NA	0.212	48.8	<0.07	101.3	268
	12-Dec-05	48.5	0.873	<0.1	0.256	16.9	<0.07	66.5	173
	24-Jan-06	292	2.05	0.116	<0.7	29	<0.7	323.2	24.8
MWT-21	07-Sep-05	192	8.32	<10	10.5	105	<7	315.8	165
(7.5' downgradient)	24-Oct-05	45.2	<0.7	NA	<0.7	18.8	<0.7	64	113
	12-Dec-05	26.7	0.484	<0.1	<0.7	3.04	<0.7	30.2	70.1
	24-Jan-06	33.2	0.36	<0.1	<0.07	<0.07	<0.07	33.6	53.5
MWT-22	07-Sep-05	521	18.1	<0.1	21	260	<7	820.1	361
(22.5' downgradient)	24-Oct-05	78.6	0.979	NA	1.02	29.9	<0.07	110.5	33.2
	12-Dec-05	28.5	0.683	<0.1	0.928	9.89	<0.07	40.0	34.5
	24-Jan-06	3.6	0.1	<0.1	<0.07	0.429	<0.07	4.1	35.5
North Transect									
MWT-12R	07-Sep-05	0.592	<0.07	<0.1	<0.07	<0.07	<0.07	0.592	7.3
(15' Upgradient)	24-Oct-05	1.39	0.07	NA	<0.07	0.28	<0.07	1.74	4.9
	12-Dec-05	0.064	<0.07	<0.1	<0.07	<0.07	<0.07	0.064	3.7
	24-Jan-06	0.208	<0.07	<0.1	<0.07	<0.07	<0.07	0.208	3.8
MWT-13	07-Sep-05	4520	462	<100	364	2580	<70	7926	296
(in western wall)	24-Oct-05	82.9	<70	NA	144	3890	11.2	4128.1	1310
	12-Dec-05	200	9.85	<1	8.73	622	<7	840.58	588
	24-Jan-06	498	16.3	1.21	6.39	201	<7	722.9	298
MWT-14	07-Sep-05	710	79.6	<10	67.5	502	<7	1359	610
(between walls)	24-Oct-05	342	8.91	NA	31.1	406	<7	788.01	432
	12-Dec-05	139	5.66	<1	2.9	265	<0.7	412.56	275
	24-Jan-06	211	3.82	<0.1	1.26	78.9	<0.7	295	209
MWT-15	07-Sep-05	106	42.4	<10	73	1040	<7	1261	1060
(in eastern wall)	24-Oct-05	49.3	<0.7	NA	<0.7	47.9	<0.07	97.2	267
	12-Dec-05	65.7	0.374	<0.1	<0.07	17	<0.07	83.1	86.7
	24-Jan-06	54.6	<0.7	<0.1	<0.7	5.43	<0.7	60.03	46.6
MWT-16	07-Sep-05	37.4	<7	<0.1	<7	53.6	<7	91	63.5
(7.5' downgradient)	24-Oct-05	66.6	1.7	NA	0.8	92.2	<0.07	161.3	204
	12-Dec-05	49.7	0.428	<0.1	<0.07	9.3	<0.07	59.4	88.6
	24-Jan-06	22.6	0.16	<0.1	<0.07	<7	<0.07	22.76	51.7
MWT-17R	07-Sep-05	0.065J	0.098	<0.1	<0.07	<0.07	<0.07	0.163	9.3
(22.5' downgradient)	24-Oct-05	48.7	0.7J	NA	0.317	41.2	<0.7	90.9	111
	12-Dec-05	31	0.136	<0.1	<0.07	<7	<0.07	31.1	63.8
	24-Jan-06	7.61	<0.07	<0.1	<0.07	<7	<0.07	7.61	29.8
MWT-22A	07-Sep-05	NA	NA	NA	NA	NA	NA	NA	NA
	24-Oct-05	NA	NA	NA	NA	NA	NA	NA	NA
	12-Dec-05								
	24-Jan-06	0.059	<0.07	<0.1	<0.07	<0.07	<0.07	0.059	6.9

TABLE 6
VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER
ASH LANDFILL MULCH BIOWALL
SENECA ARMY DEPOT, ROMULUS, NEW YORK

Sample Identification	Sample Date	PCE ug/L	TCE ug/L	1,1-DCE ug/L	*cis*-1,2-DCE ug/L	*trans*-1,2-DCE ug/L	VC ug/L	1,1-DCA ug/L	Acetone ug/L	2-Butanone ug/L	2-Hexanone ug/L
South Transect											
PT-12A	07-Sep-05	50 U	860	50 U	910	50 U	50 U	50 U	50 U	50 U	50 U
(15' Upgradient)	24-Oct-05	1 U	730	1.3	800	11	24	1 U	5 U	5 U	5 U
	12-Dec-05	1 U	385	0.55 J	315	4.9	8.2	1 U	5 U	5 U	5 U
	24-Jan-06	1 U	530	1 U	400	5.6	19	1 U	50 U	50 U	13 J
MWT-18	07-Sep-05	50 U	28 J	50 U	120	50 U	50 U	50 U	1200 J	2500 J	27 J
(in western wall)	24-Oct-05	20 U	20 U	20 U	190	20 U	20 U	20 U	3000	4400	100 U
	12-Dec-05	5 U	5 U	5 U	230	5 U	23	5 U	4700 J	7600	49
	24-Jan-06	20 U	20 U	20 U	150	20 U	26	20 U	1800	5800	100 U
MWT-19	07-Sep-05	10 U	110	2 J	1300	13	17	10 U	370	600	4 J
(between walls)	24-Oct-05	5 U	33	5 U	1600	21	18	5 U	190	200	25 U
	12-Dec-05	5 U	17	2.1 J	1000	17	140 J	5 U	180	330	25 U
	24-Jan-06	1U	22	1.4	870	20	345	1 U	170 J	455 J	5.7 J
MWT-20	07-Sep-05	250 U	250 U	250 U	160 J	250 U	250 U	250 U	3200	1700	250 U
(in eastern wall)	24-Oct-05	5 U	5 U	5 U	160	2.9 J	16	5 U	270 J	990 J	34
	12-Dec-05	5 U	5 U	5 U	13	2.2 J	13 J	5 U	200	260	25 U
	24-Jan-06	1 U	1 U	1 U	8.4	1.8	9.1	1 U	410 J	660	17 J
MWT-21	07-Sep-05	100 U	98 J	100 U	1200	100 U	100 U	100 U	250	270	100 U
(7.5' downgradient)	24-Oct-05	1 U	45	2.4 J	1400	38	69	1 U	350 J	310 J	6
	12-Dec-05	5 U	20	5 U	570	22	180	5 U	73	66	25 U
	24-Jan-06	1 U	18	0.74 J	470	20	180	1 U	130 J	110 J	5 UJ
MWT-22	07-Sep-05	100 U	100 U	100 U	1000	100 U	100 U	100 U	400	480	100 U
(22.5' downgradient)	24-Oct-05	5 U	25	5 U	1100	17	170	5 U	340	310	25 U
	12-Dec-05	5 U	12	5 U	360	11	140	5 U	66	89	25 U
	24-Jan-06	1 U	25	0.72 J	430	13	140	1 U	14 J	12 J	5 UJ
North Transect											
MWT-12R	07-Sep-05	80 U	705	80 U	965	80 U	86	80 U	80 U	80 U	80 U
(15' Upgradient)	24-Oct-05	1 U	725	2.7	895	23	85	1 U	3.5 J	5 U	5 U
	12-Dec-05	1 U	760	2.9	980	21	64	1 U	3.8 J	5 U	5 U
	24-Jan-06	1 U	540	2.3	650	17	67	1 U	5.6 J	5 UJ	5 UJ
MWT-13	07-Sep-05	250 U	250 U	250 U	320	250 U	250 U	250 U	1600	2700	250 U
(in western wall)	24-Oct-05	20 U	20 U	20 U	410	20 U	20 U	20 U	8000	9300	100 U
	12-Dec-05	10 U	10 U	10 U	220	10 U	41	10 U	4900	6000	62
	24-Jan-06	1 U	1 U	1 U	52	1.9	55	1 U	1600	2000	38 J
MWT-14	07-Sep-05	50 U	170	50 U	1000	50 U	50 U	50 U	660	910	50 U
(between walls)	24-Oct-05	10 U	10 U	10 U	1600	22	10	10 U	2800	2900	50 U
	12-Dec-05	10 U	10 U	10 U	550	15	230	10 U	2300	2800	36 J
	24-Jan-06	1 U	2	1 U	140	11	340	1 U	770	930	17 J
MWT-15	07-Sep-05	50 U	50 U	50 U	170	50 U	50 U	50 U	3400	820	50 U
(in eastern wall)	24-Oct-05	20 U	20 U	20 U	140	20 U	36	20 U	140	690	100 U
	12-Dec-05	5 U	5 U	5 U	15	2.6 J	10	5 U	130	140	25 U
	24-Jan-06	1 U	1 U	1 U	3.1	2.2	5	1 U	55 J	33 J	5 UJ
MWT-16	07-Sep-05	20 U	70	20 U	160	20 U	20 U	20 U	270	120	20 U
(7.5' downgradient)	24-Oct-05	20 U	9.5 J	20 U	380	20 U	51	20 U	740	750	100 U
	12-Dec-05	5 U	2.5 J	5 U	58	5.3	31	5 U	85	210	25 U
	24-Jan-06	1 U	2.9	1 U	43	5.4	31	1 U	24 J	15 J	5 UJ
MWT-17R	07-Sep-05	10 U	33	10 U	59	10 U	10 U	10 U	10 U	10 U	10 U
(22.5' downgradient)	24-Oct-05	1 U	16	1 U	380	5.9	19	1 U	430 J	290 J	3.6 J
	12-Dec-05	5 U	4.8 J	5 U	120	4.4 J	42	5 U	79	180	25 U
	24-Jan-06	1 U	12	1 U	97	4.2	60	1 U	11	6.2	5 U
Downgradient Well											
PT-22	01-Dec-05	1 U	46	1 U	120	2.3	17	1 U	5 UJ	5 UJ	5 UJ
	12-Dec-05	1 U	42	1 U	160 J	3.8	30	1 U	3.8 J	5 U	5 U
	24-Jan-06	1 U	37	1 U	110	2.6	26	1 U	5 UJ	5 UJ	5 UJ

Note:

1) Sample duplicate pairs were collected for MWT-12R in Sep-05 and Oct-05, for PT-12A in Dec-05, and MWT-19 for Jan-06 sampling events. Non-detected values were reported at full value. If an analyte was detected in the sample but not detected in the duplicate (or vice versa), the non-detect value was taken at half and averaged with the detected value.

TABLE7A

PERCENT REDUCTIONS OF TCE AND TOTAL CHLOROETHENES
ASH LANDFILL MULCH BIOWALL
SENECA ARMY DEPOT, ROMULUS, NEW YORK

Reductions in Concentration of TCE [a/]

	Northern Flow Path			Southern Flow Path		
Date	TCE MWT-12R (µg/L)[b/]	TCE MWT-15 (µg/L)	Percent Reduction TCE	TCE PT-12A (µg/L)	TCE MWT-20 (µg/L)	Percent Reduction TCE
September-05	705	<1.6	**99.9%**	860	<8.1	**99.5%**
October-05	725	<10	**99.3%**	730	<2.5	**99.8%**
December-05	760	<5	**99.7%**	400	<5	**99.4%**
January-06	540	<1	**99.9%**	530	<1	**99.9%**

Reductions in Molar Concentration of Total Chloroethenes

	Northern Flow Path			Southern Flow Path		
Date	Total Molar Chlorethenes MWT-12R (nmol/L)[c/]	Total Molar Chlorethenes MWT-15 (nmol/L)c/	Percent Reduction Total Molar Chloroethenes	Total Molar Chlorethenes PT-12A (nmol/L)[c/]	Total Molar Chlorethenes MWT-20 (nmol/L)c/	Percent Reduction Total Molar Chloroethenes
September-05	16,731	1,791	**89.3%**	15,964	1,838	**88.5%**
October-05	16,190	2,192	**86.5%**	14,321	1,966	**86.3%**
December-05	17,167	401	**97.7%**	6,370	425	**93.3%**
January-06	12,089	147	**98.8%**	8,530	263	**96.9%**

[a/] TCE = trichloroethene

[b/] µg/L = micrograms per liter.

[c/] nmol/L = nanomoles per liter.

TABLE 7B
PERCENT REDUCTIONS OF TCE AND TOTAL CHLOROETHENES
ASH LANDFILL MULCH BIOWALL
SENECA ARMY DEPOT, ROMULUS, NEW YORK

Northern Flow Path - Downgradient

Reductions in Concentration of TCE [a]

	Immediately Downgradient			Further Downgradient		
Date	TCE MWT-12R (µg/L) [b]	TCE MWT-16 (µg/L)	Percent Reduction TCE	TCE MWT-12R (µg/L) [b]	TCE MWT-17R (µg/L)	Percent Reduction TCE
September-05	705	70	**90.1%**	705	33	**95.3%**
October-05	725	9.5	**98.7%**	725	16	**97.8%**
December-05	760	<5	**99.7%**	760	4.8	**99.4%**
January-06	540	2.9	**99.5%**	540	12	**97.8%**

Reductions in Molar Concentration of Total Chloroethenes

	Immediately Downgradient			Further Downgradient		
Date	Total Molar Chlorethenes MWT-12R (nmol/L) [c]	Total Molar Chlorethenes MWT-16 (nmol/L)	Percent Reduction Total Molar Chloroethenes	Total Molar Chlorethenes MWT-12R (nmol/L) [c]	Total Molar Chlorethenes MWT-17R (nmol/L)	Percent Reduction Total Molar Chloroethenes
September-05	16,731	2,196	**86.9%**	16,731	866	**94.8%**
October-05	16,190	4,942	**69.5%**	16,190	4,411	**72.8%**
December-05	17,167	1,209	**93.0%**	17,167	2,033	**88.2%**
January-06	12,089	1,026	**91.5%**	12,089	2,103	**82.6%**

[a] TCE = trichloroethene

[b] µg/L = micrograms per liter.

[c] nmol/L = nanomoles per liter

TABLE 7B
PERCENT REDUCTIONS OF TCE AND TOTAL CHLOROETHENES
ASH LANDFILL MULCH BIOWALL
SENECA ARMY DEPOT, ROMULUS, NEW YORK

Southern Flow Path - Downgradient

Reductions in Concentration of TCE [a]

	Immediately Downgradient			Immediately Downgradient		
Date	TCE PT-12A (µg/L)	TCE MWT-21 (µg/L)	Percent Reduction TCE	TCE PT-12A (µg/L)	TCE MWT-22 (µg/L)	Percent Reduction TCE
September-05	860	98	**88.6%**	860	<3.2	**99.8%**
October-05	730	45	**93.8%**	730	25	**96.6%**
December-05	385	20	**94.8%**	385	12	**96.9%**
January-06	530	18	**96.6%**	530	25	**95.3%**

Reductions in Molar Concentration of Total Chloroethenes

	Immediately Downgradient			Further Downgradient		
Date	Total Molar Chlorethenes PT-12A (nmol/L)[c]	Total Molar Chlorethenes MWT-21 (nmol/L)	Percent Reduction Total Molar Chloroethenes	Total Molar Chlorethenes PT-12A (nmol/L)[c]	Total Molar Chlorethenes MWT-22 (nmol/L)	Percent Reduction Total Molar Chloroethenes
September-05	15,964	13,187	**17.4%**	15,964	10,391	**34.9%**
October-05	14,321	16,307	**-13.9%**	14,321	14,453	**-0.9%**
December-05	6,370	9,180	**-44.1%**	6,370	6,199	**2.7%**
January-06	8,530	8,082	**5.2%**	8,530	7,011	**17.8%**

[a] TCE = trichloroethene
[b] µg/L = micrograms per liter.
[c] nmol/L = nanomoles per liter.

Table 8
Characteristics of Chlorinated Aliphatic Hydrocarbons and Dechlorination Products
Ash Landfill Mulch Biowall
Seneca Army Depot Activity, Romulus, NY

Compound	Molecular Formula	Molecular Weight (g/mol)[a/]	Density (g/mL @ approx. 20 to 25 °C)[b/]	Henry's Law Constant (atm-m³/mol)[e/]	Solubility (mg/L @ approx. 20 to 25 °C)[c/]	Vapor Pressure (mm Hg @ 20 °C)[d/]	Octanol/Water Partition Coefficient (log Kow)[f/]	Octanol/Carbon Partition Coefficient (log Koc)[g/]
Chloroethenes								
Trichloroethene (TCE)	C_2HCl_3	131.4 (1)	1.46 (1)	0.0072 (2)	1,100 (3)	60.0 (3)	2.42 (4)	2.03 (5)
cis-1,2- Dichloroethene (*cis*-DCE)	$C_2H_2Cl_2$	96.94 (1)	1.28 (1)	0.0030 (2)	3,500 (3)	200 (6)	0.70	1.65 (7)
trans-1,2- Dichloroethene (*trans*-DCE)	$C_2H_2Cl_2$	96.94 (1)	1.26 (1)	0.0073 (2)	6,300 (4)	340 (6)	2.06 (7)	1.77 (5)
1,1-Dichloroethene (1,1-DCE)	$C_2H_2Cl_2$	96.94 (1)	1.22 (1)	0.021 (2)	2,250 (5)	500 (3)	2.13 (4)	1.81 (5)
Vinyl Chloride (VC)	C_2H_3Cl	62.51 (1)	Gas	0.218 (2)	1,100 (3)	2,660 (3)	0.60 (4)	1.23 (5)
Ethene	C_2H_4	28.05 (1)	Gas	8.60 (7)	131 (7)	30,800 (7)	1.13 (8)	2.48 (7)
Chloroethanes								
1,1,1-Trichloroethane (1,1,1-TCA)	$C_2H_3Cl_3$	133.4 (1)	1.34 (1)	0.0133 (2)	4,400 (3)	100 (3)	2.47 (4)	2.02 (5)
1,1,2-Trichloroethane (1,1,2-TCA)	$C_2H_3Cl_3$	133.4 (1)	1.44 (1)	0.0012 (7)	4,500 (3)	19 (3)	2.18 (4)	1.75 (5)
1,1-Dichloroethane (1,1-DCA)	$C_2H_4Cl_2$	98.96 (1)	1.18 (1)	0.0043 (2)	5,500 (3)	180 (3)	1.78 (4)	1.48 (5)
1,2-Dichloroethane (1,2-DCA)	$C_2H_4Cl_2$	98.96 (1)	1.24 (1)	0.00098 (6)	8,690 (3)	61 (3)	1.48 (4)	1.28 (5)
Chloroethane (CA)	C_2H_5Cl	64.51 (1)	Gas	0.0094 (2)	5,740 (3)	1,010 (3)	1.43 (4)	1.42 (7)
Ethane	C_2H_6	30.07 (1)	Gas	19.2 (7)	60.4 (3)	29,300 (3)	1.81 (8)	2.66 (7)

a/ g/mol = grams per mole.
b/ g/ml = grams per milliliter; °C = degrees Celsius.
c/ mg/L = milligrams per liter.
d/ mm Hg = vapor pressure measured as millimeters of mercury.
e/ atm-m³/mol = atmospheres-cubic meter per mole.
f/ log Kow = log of octanol/water partition coefficient (dissolution coefficient).
g/ log Koc = log of octanol/carbon coefficient (soil sorption coefficient).

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TABLE 9A

PERCENT REDUCTIONS IN TCE AND TOTAL CHLOROETHENES IN THE ZVI WALL
ASH LANDFILL MULCH BIOWALL
SENECA ARMY DEPOT, ROMULUS, NEW YORK

Within Walls

Reductions in Concentration of TCE [a/]

	North Transect			Middle Transect			South Transect		
Date	TCE MWT-1 (μg/L)[b/]	TCE MWT-2 (μg/L)	Percent Reduction TCE	TCE MWT-4 (μg/L)	TCE MWT-5 (μg/L)	Percent Reduction TCE	TCE MWT-7 (μg/L)	TCE MWT-8 (μg/L)	Percent Reduction TCE
TS Rounds									
April-99	23	1	**95.7%**	2	<1	**75.0%**	430	<1	99.9%
June-99	8	<1	**93.8%**	2	<1	**75.0%**	530	<2	99.8%
September-99	<2	<1	**N/A**	<3	<1	N/A	480	<1	99.9%
January-00	18	<2	**94%**	<3	<1	N/A	480	<3	99.7%
Latest Rounds									
March-04	17	3.2	**81.4%**	2.6	<0.5	**90.4%**	386	<0.5	**99.9%**
August-04	22	0.8	**96.4%**	3.9	<0.24	**96.9%**	280	1.8	**99.4%**

Reductions in Molar Concentration of Total Chloroethenes

	Northern Transect			Middle Transect			Southern Transect		
Date	Total Molar Chlorethenes MWT-1 (nmol/L)[c/]	Total Molar Chlorethenes MWT-2 (nmol/L)[c/]	Percent Reduction Total Molar Chloroethenes	Total Molar Chloroethenes MWT-4 (nmol/L)	Total Molar Chlorethenes MWT-5 (nmol/L)	Percent Reduction Total Molar Chloroethenes	Total Molar Chloroethenes MWT-7 (nmol/L)	Total Molar Chlorethenes MWT-8 (nmol/L)	Percent Reduction Total Molar Chloroethenes
TS Rounds									
April-99	981	299	69.5%	560	24	95.7%	3,768	22	99.4%
June-99	417	79	81.1%	914	231	74.7%	4,772	467	90.2%
September-99	81	21	74.1%	457	66	85.6%	4,352	87	98.0%
January-00	924	267	71.1%	643	87	86.5%	4,222	612	85.5%
Latest Rounds									
March-04	565	216	**61.8%**	700	134	**80.9%**	3,159	898	**71.6%**
August-04	1,260	178	**85.9%**	676	60	**91.1%**	2,463	1,593	**35.3%**

[a/] TCE = trichloroethene
[b/] μg/L = micrograms per liter.
[c/] nmol/L = nanomoles per liter.

TABLE 9B

PERCENT REDUCTIONS IN TCE AND TOTAL CHLOROETHENES IN ZVI WALL
ASH LANDFILL MULCH BIOWALL
SENECA ARMY DEPOT, ROMULUS, NEW YORK

Downgradient of Wall

Reductions in Molar Concentration of Total Chloroethenes

Date	Northern Transect			Middle Transect			Southern Transect		
	Total Molar Chlorethenes MWT-1 (nmol/L)[c]	Total Molar Chlorethenes MWT-3 (nmol/L)[c]	Percent Reduction Total Molar Chloroethenes	Total Molar Chloroethenes MWT-4 (nmol/L)	Total Molar Chlorethenes MWT-6 (nmol/L)	Percent Reduction Total Molar Chloroethenes	Total Molar Chloroethenes MWT-7 (nmol/L)	Total Molar Chlorethenes MWT-9 (nmol/L)	Percent Reduction Total Molar Chloroethenes
TS Rounds									
April-99	981	312	68.2%	560	48	91.4%	3,768	684	81.8%
June-99	417	122	70.7%	914	196	78.6%	4,772	2,048	57.1%
September-99	81	35	56.8%	457	128	72.0%	4,352	862	80.2%
January-00	924	543	41.2%	643	118	81.6%	4,222	730	82.7%
Latest Rounds									
March-04	565	307	45.7%	700	144	79.4%	3,159	1,506	52.3%
August-04	1,260	410	67.5%	676	193	71.4%	2,463	2,922	-18.6%

[a] TCE = trichloroethene

[b] µg/L = micrograms per liter.

[c] nmol/L = nanomoles per liter.

Table 10
Treatment Zone Indicator Parameters
Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

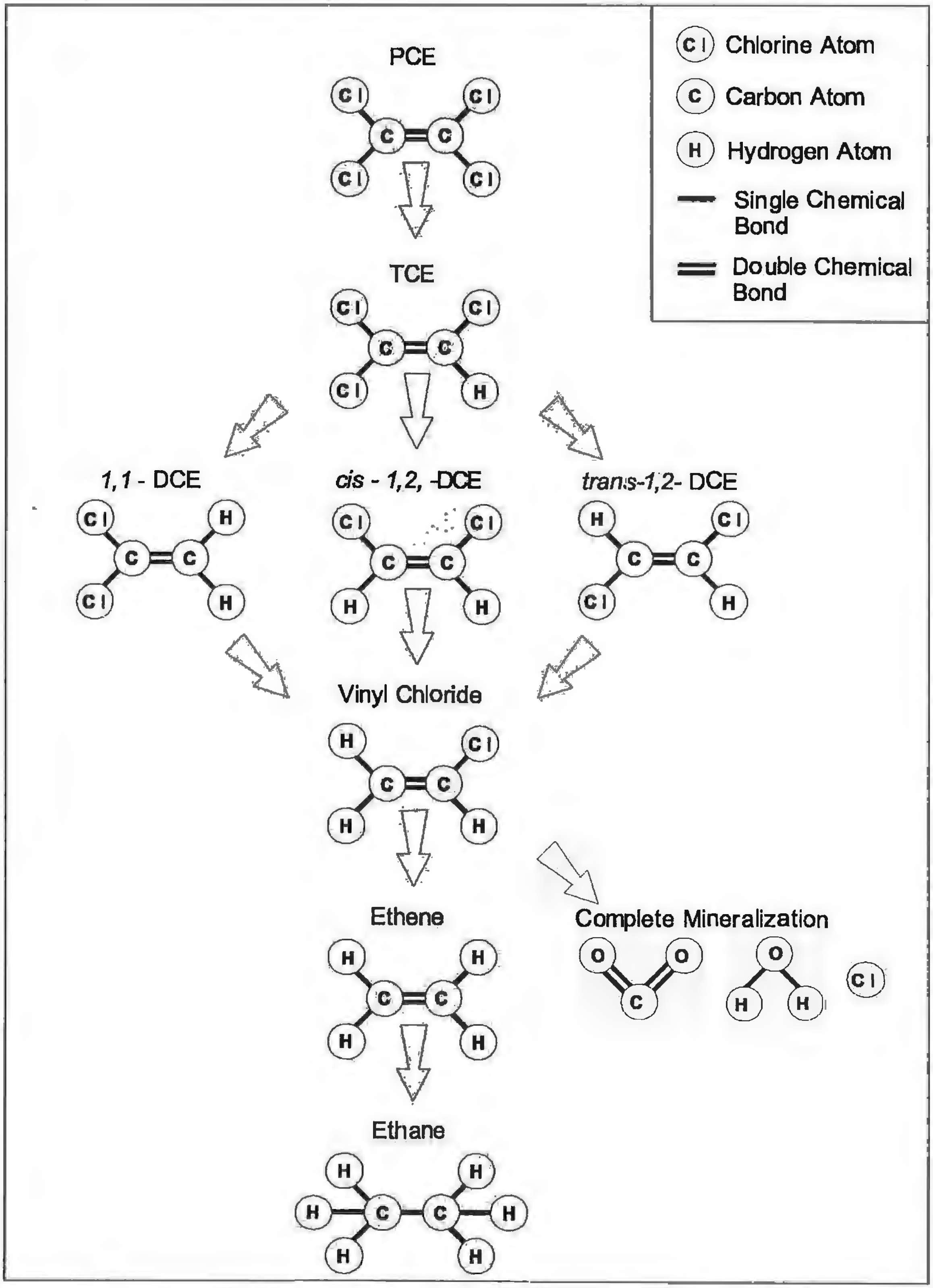
NORTH TRANSECT Parameter	Indicator Value [1]	MW-39 Background	MWT-12R Upgradient	MWT-13 & MWT-15 Average In Walls	MWT-14 & MWT-16 Treatment Zone Immediately Downgradient	MWT-17R Further Downgradient	PT-22 Further Downgradient
Dist. from Biowall (ft.)		N/A	-15	0	7.5	22.5	~140
Oxygen	<0.5 mg/L	0.31	0.56	0.14	0.17	0.29	0.1
Iron (ferrous)	>1.0 mg/L	4	0	2.87	2.64	3.3	0.17
Sulfate	<20 mg/L	27.2	741	17.6	39.9	58.5	78.3
CO_2	>2x background	400	656	1,000	983	960	380
ORP	<-100 mV	76	54	-150	-121	-156	-91
Methane	>500 ug/L	0.79	150	21,000	12,500	7,300	970
Volatile Fatty Acids [2]	>0.1 mg/L	ND	0.21	403	199	7.61	0.059
TOC	>20 mg/L	<1.0	3.8	172	130	29.8	6.9
Temperature	>20 degrees C	9.85	7.40	6.95	7.30	6.7	7
Alkalinity	>2x background	212	296	623	904	781	472
Chlorides	>2x background	2.8	169	59.8	50.0	23.7	16.9

SOUTH TRANSECT Parameter	Indicator Value [1]	MW-39 Background	PT-12A Upgradient	MWT-18 & MWT-20 Average In Walls	MWT-19 & MWT-21 Treatment Zone Immediately Downgradient	MWT-22 Further Downgradient	PT-22 Further Downgradient
Dist. from Biowall (ft.)			-15	0	7.5	22.5	~140
Oxygen	<0.5 mg/L	0.31	0.39	0.07	0.08	0.15	0.1
Iron (ferrous)	>1.0 mg/L	4	0.16	3.21	2.86	2.3	0.17
Sulfate	<20 mg/L	27.2	585	<4	97.15	370	78
CO_2	>2x background	400	380	993	960	722	380
ORP	<-100 mV	76	93	-161	-265	-104	-91
Methane	>500 ug/L	0.79	26	18,500	7,425	2,300	970
Volatile Fatty Acids [2]	>0.1 mg/L	ND	0.048	675.7	72.2	4.095	0.059
TOC	>20 mg/L	<1.0	4.2	375	63.8	35.5	6.9
Temperature	>20 degrees C	9.85	7.0	7.6	7.45	8.3	7.00
Alkalinity	>2x background	212	320	1,213	1,043	731	472
Chlorides	>2x background	2.8	40.3	68.1	60.6	63.5	16.9

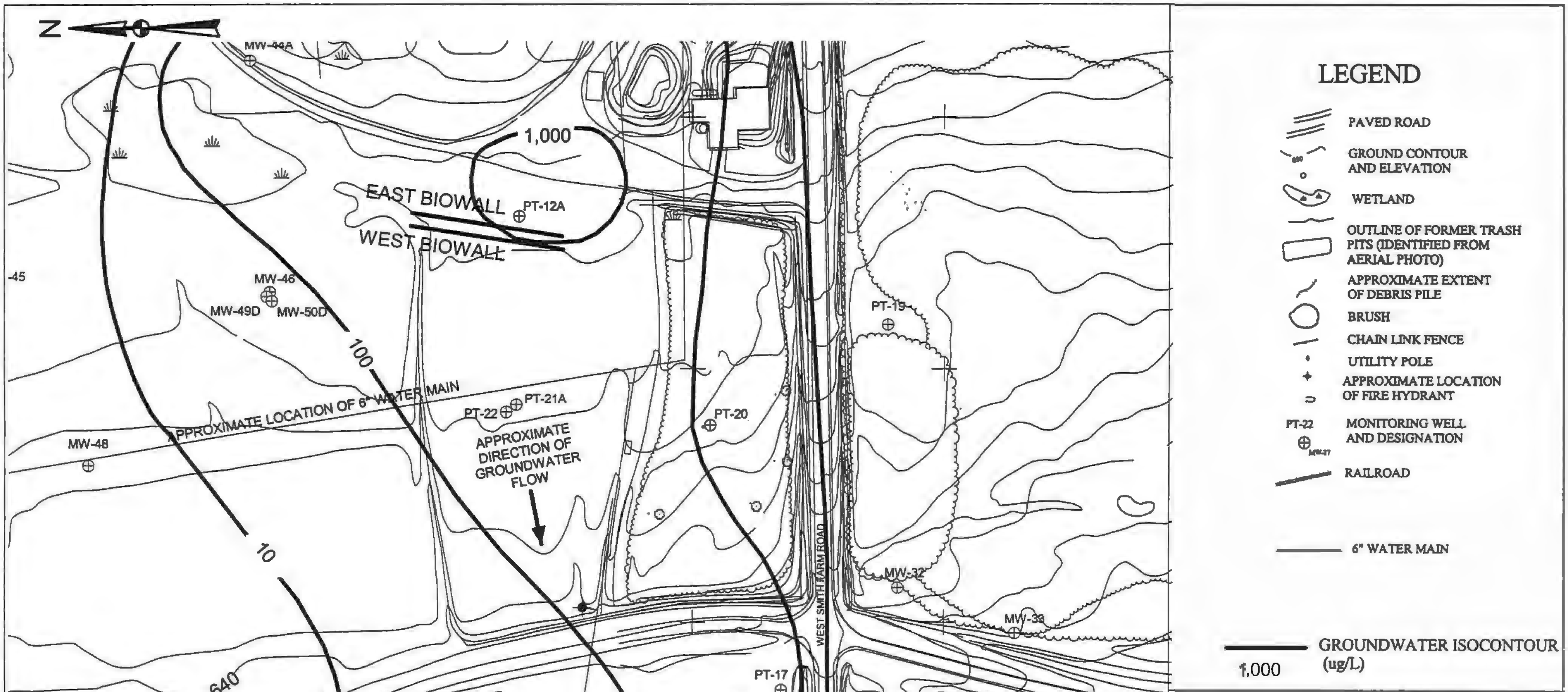
Notes:
Laboratory and field data for the biowall monitoring network were recorded during Round 4 of sampling in January 2006. Data from the background well (MW-39) was sampled once in December 2005 and the far downgradient well (PT-22) were collected on 1/28/06.
(1) Indicator values are listed in "Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater" (USEPA, 1998).
(2) Volatile fatty acid concentrations are the sum of detected concentrations of acetic acid, butyric acid, hexanoic acid, pentatonic acid, propionic acid, and pyruvic acid.

FIGURES

Figure 1
Reductive Dechlorination of Chlorinated Ethenes
Ash Landfill Biowall Pilot Study
Seneca Army Depot Activity



(USEPA, 1998)



PARSONS

SENECA ARMY DEPOT ACTIVITY

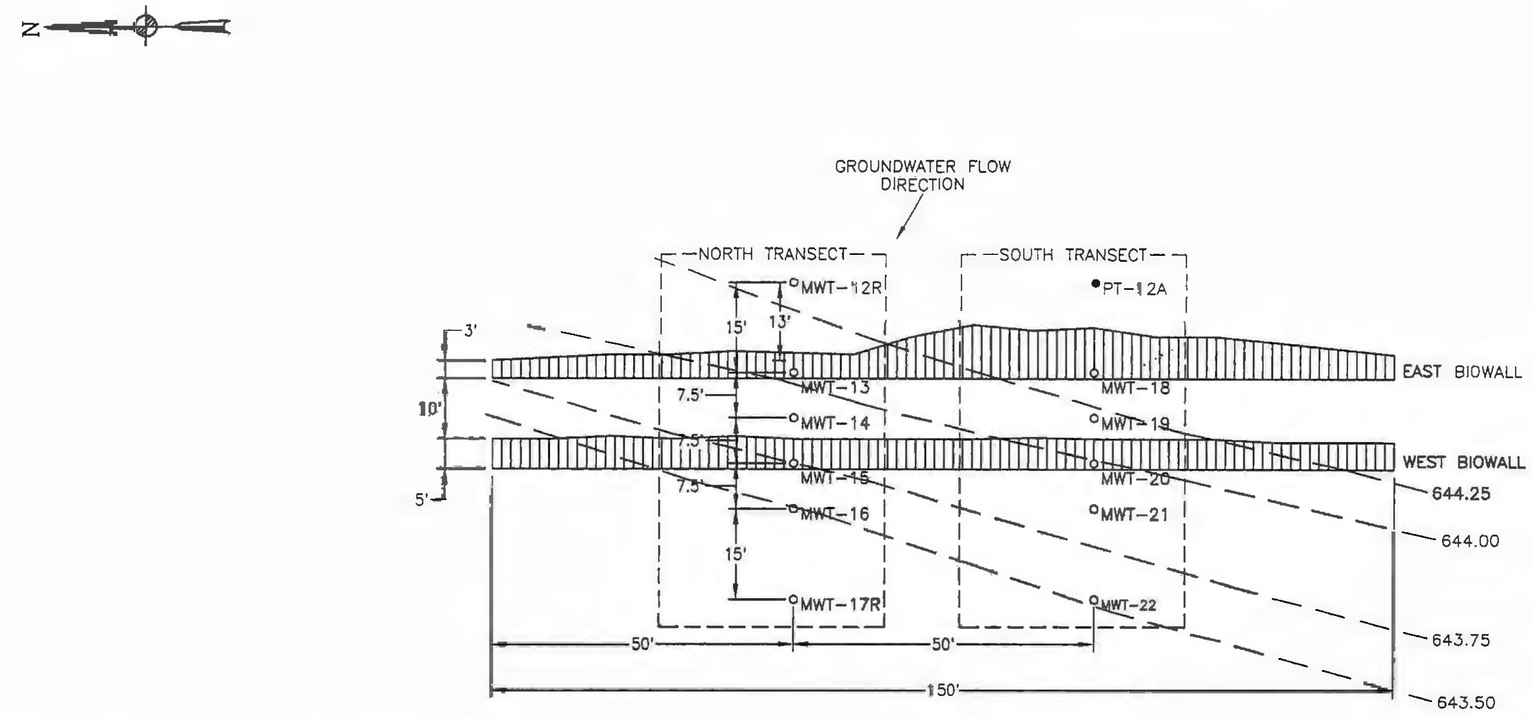
ASH LANDFILL BIOWALL PILOT STUDY

ENVIRONMENTAL ENGINEERING	744538-01000

FIGURE 2
APPROXIMATE LOCATION OF BIOWALLS AND TOTAL CHLORINATED ETHENES IN GROUNDWATER

SCALE: 1" = 150'	MARCH 2006

O:\Seneca\Ash_lf\Ash RD WP\ash_rd_wp.apr



LEGEND

●PT-12A 2" GROUNDWATER MONITORING WELL INSTALLED PRE-BIOWALL INSTALLATION

○MWT-17 2" GROUNDWATER MONITORING WELL INSTALLED POST-BIOWALL INSTALLATION

BIOWALL

20' 10' 0 20'

SCALE: 1" = 20'

PARSONS

SENECA ARMY DEPOT ACTIVITY
ASH LANDFILL
BIOWALL PILOT STUDY

ENVIRONMENTAL ENGINEERING | 744636-01100

FIGURE 3
GROUNDWATER ELEVATIONS IN
BIOWALL MONITORING NETWORK
SEPTEMBER 7, 2005

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Figure 4
Fraction of Total Ethenes Along the North Transect - Round 2

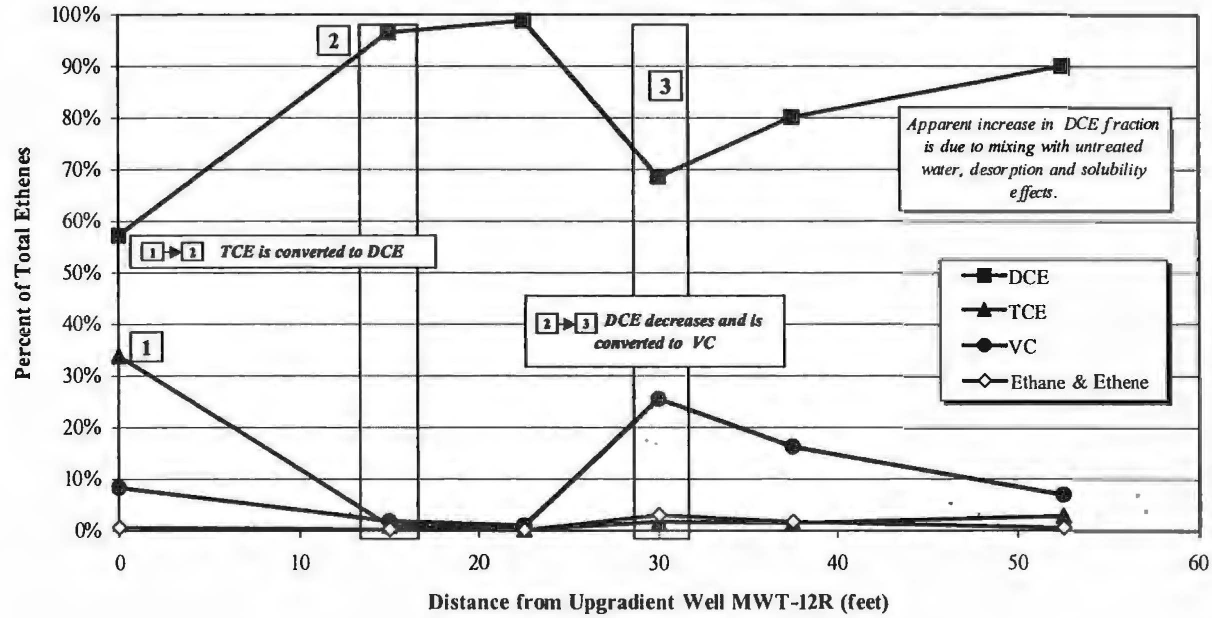
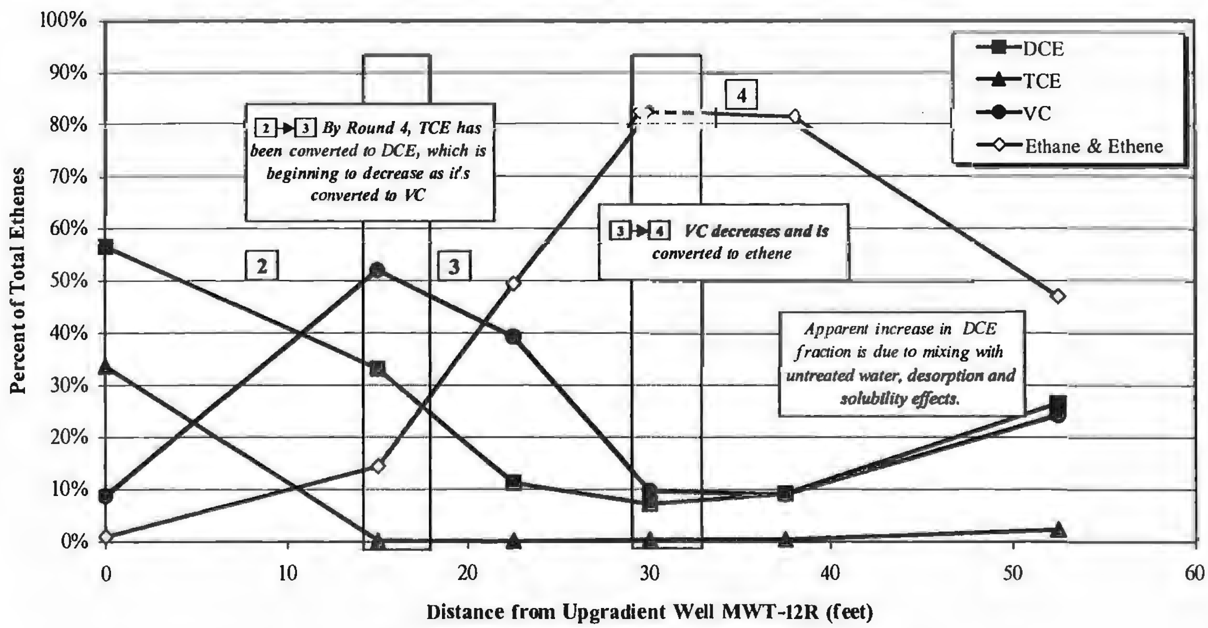
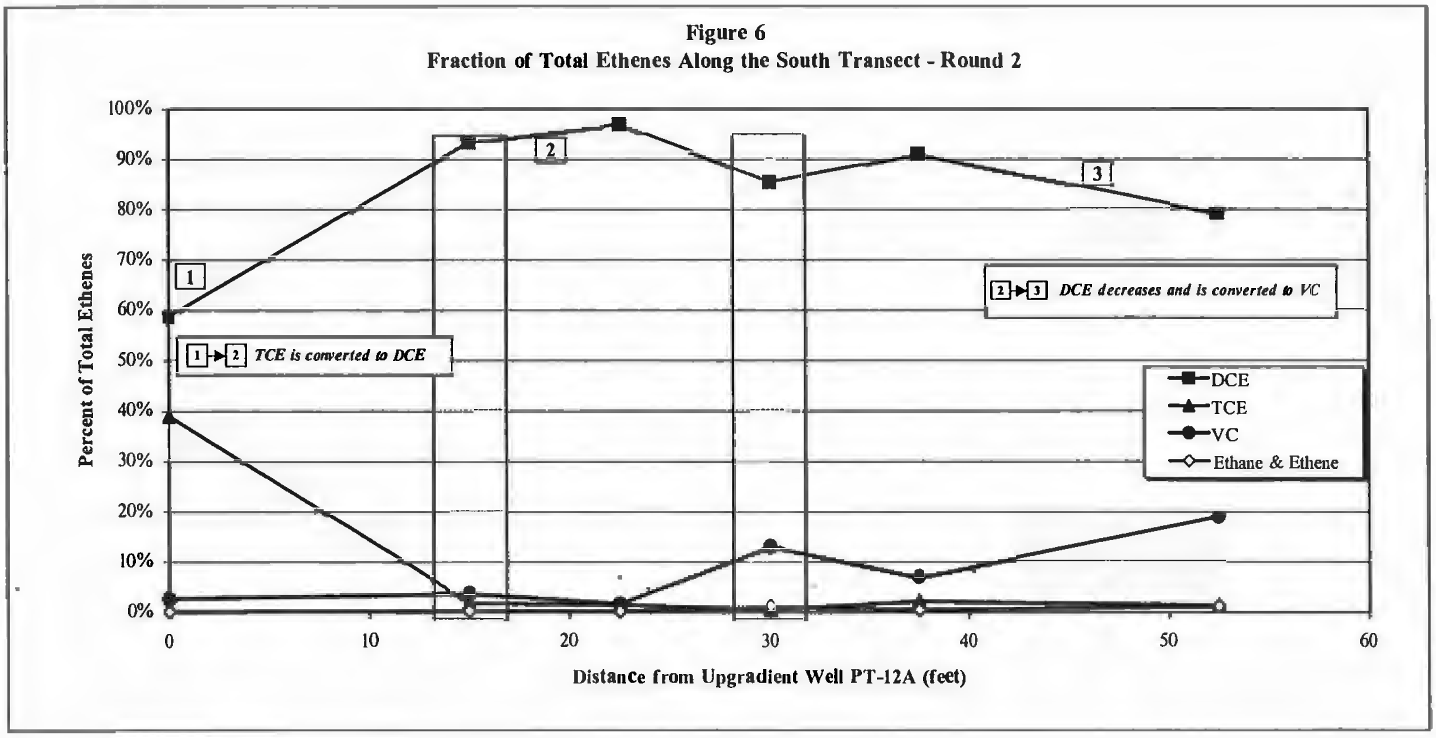


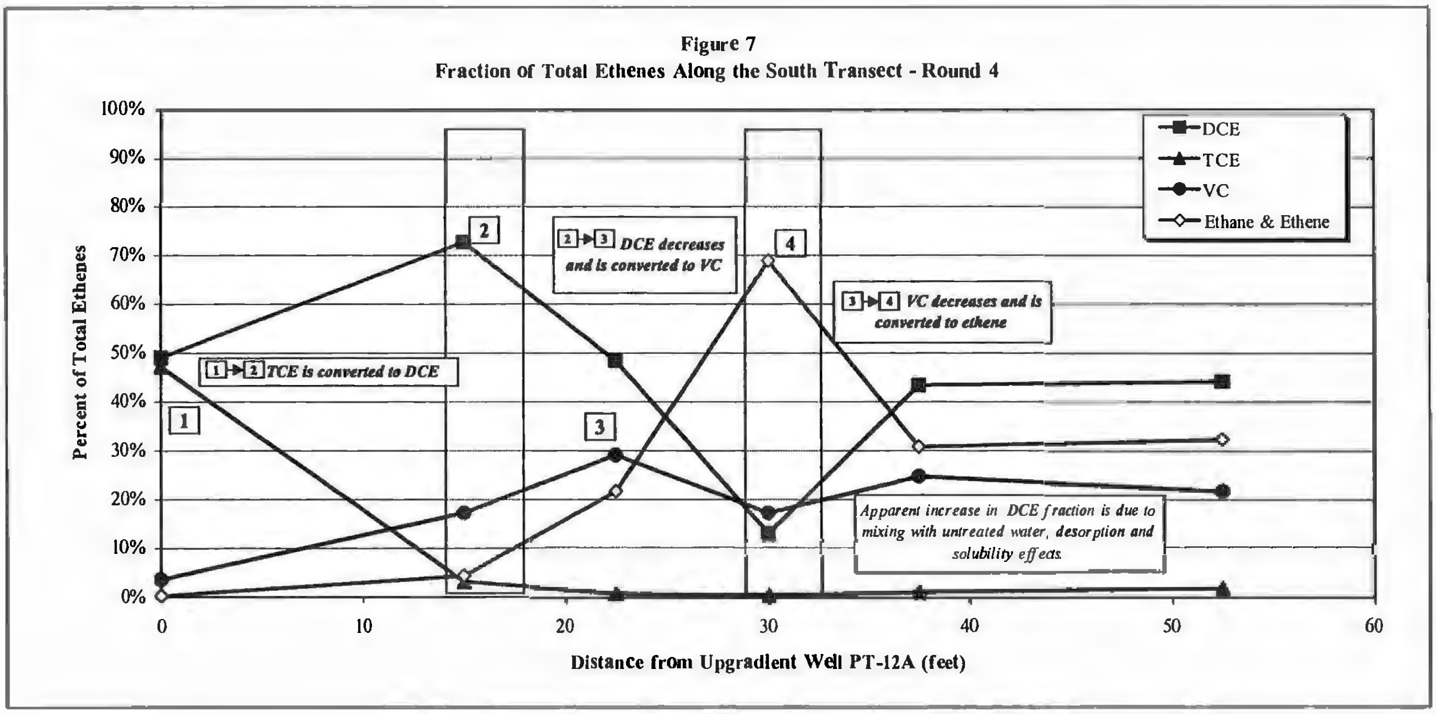
Figure 5
Fraction of Total Ethenes Along the North Transect - Round 4



Note: The bolded numbers (1 through 4) denote the dominant step of the dechlorination process shown in the schematic in Section 4.4.

P:\PIT\Projects\Seneca PBC I\Pilot Study Report\Draft Report\Tables\Total Molar Ethenes.xls\North T Figure 4&5





Note: The bolded numbers (1 through 4) denote the dominant step of the dechlorination process shown in the schematic in Section 4.4.

P:\PIT\Projects\Seneca PBC I\Pilot Study Report\Draft Report\Tables\Total Molar Ethenes.xls\South T Figure 6&7

Figure 8
Changes in Fraction of Total Ethenes Over Time for MWT-13
1st Wall (North Transect)

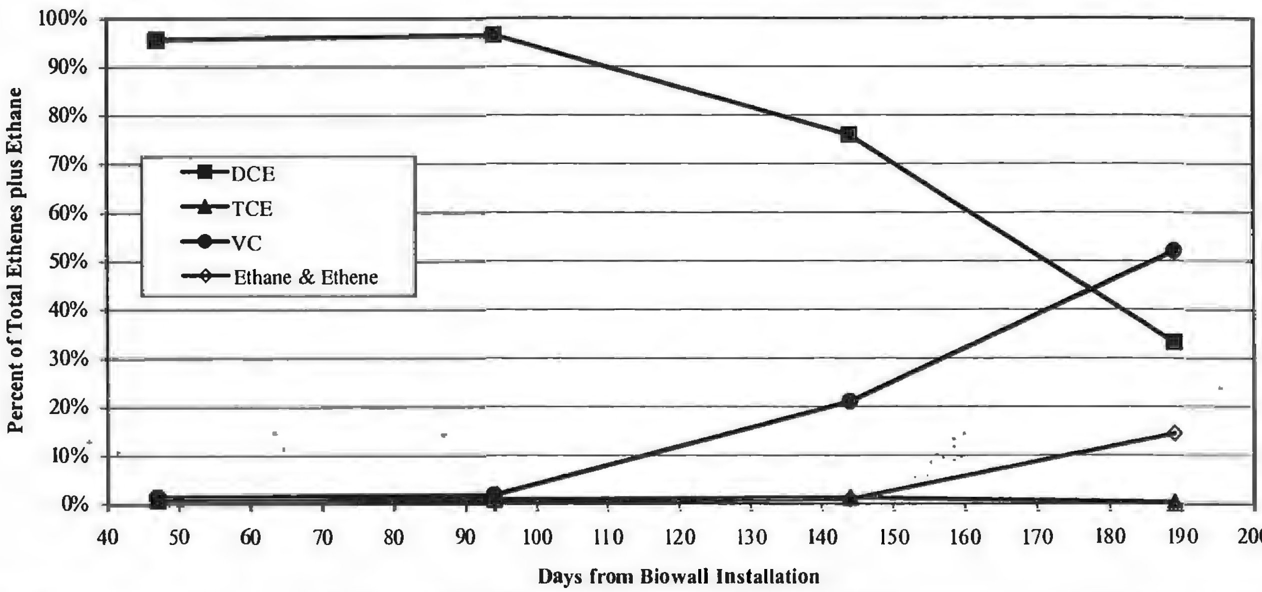


Figure 9
Changes in Fraction of Total Ethenes Over Time for MWT-18
1st Wall (South Transect)

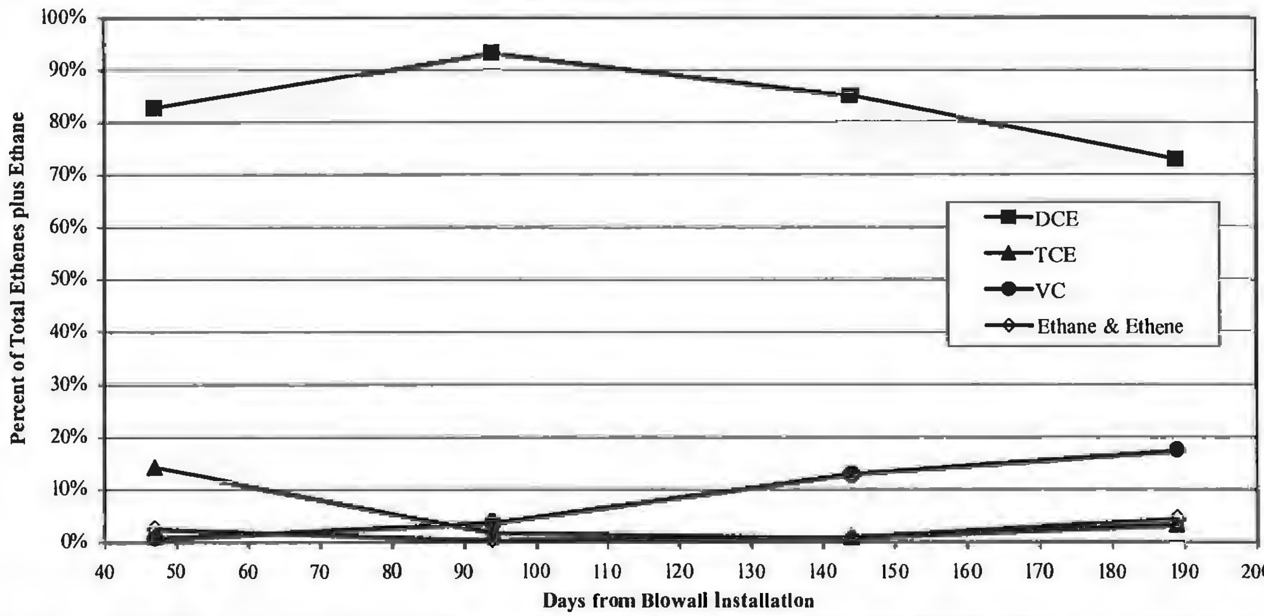


Figure 10
Changes in Fraction of Total Ethenes Over Time for MWT-16
1st Downgradient Well (North Transect)

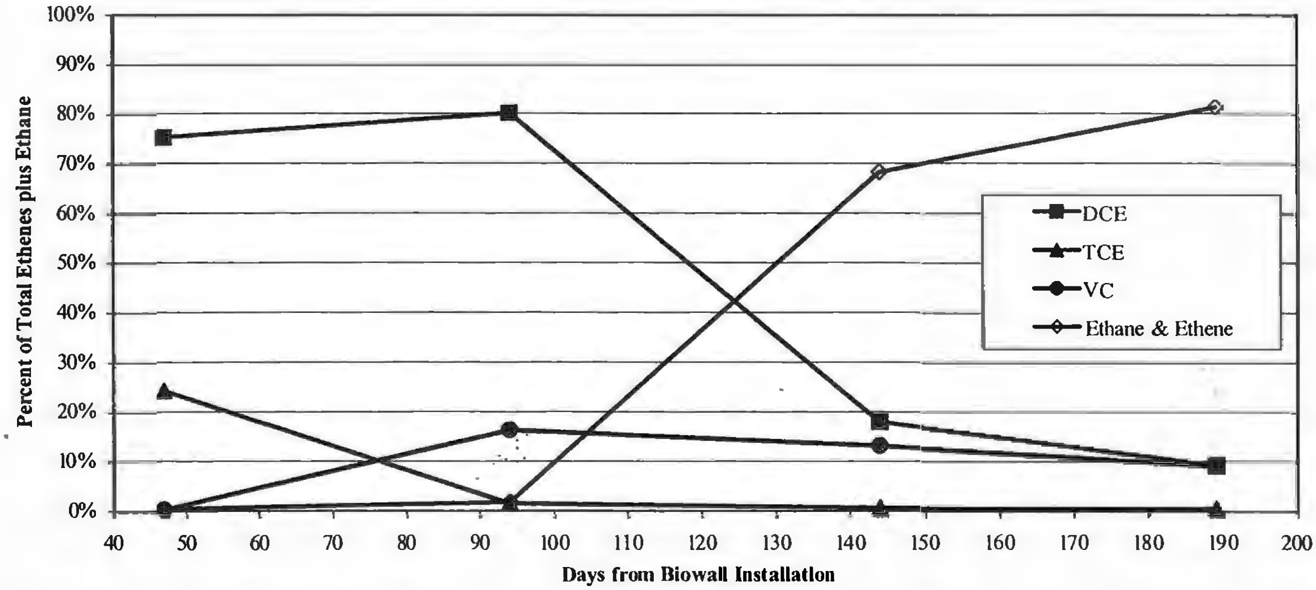


Figure 11
Changes in Fraction of Total Ethenes Over Time for MWT-21
1st Downgradient Well (South Transect)

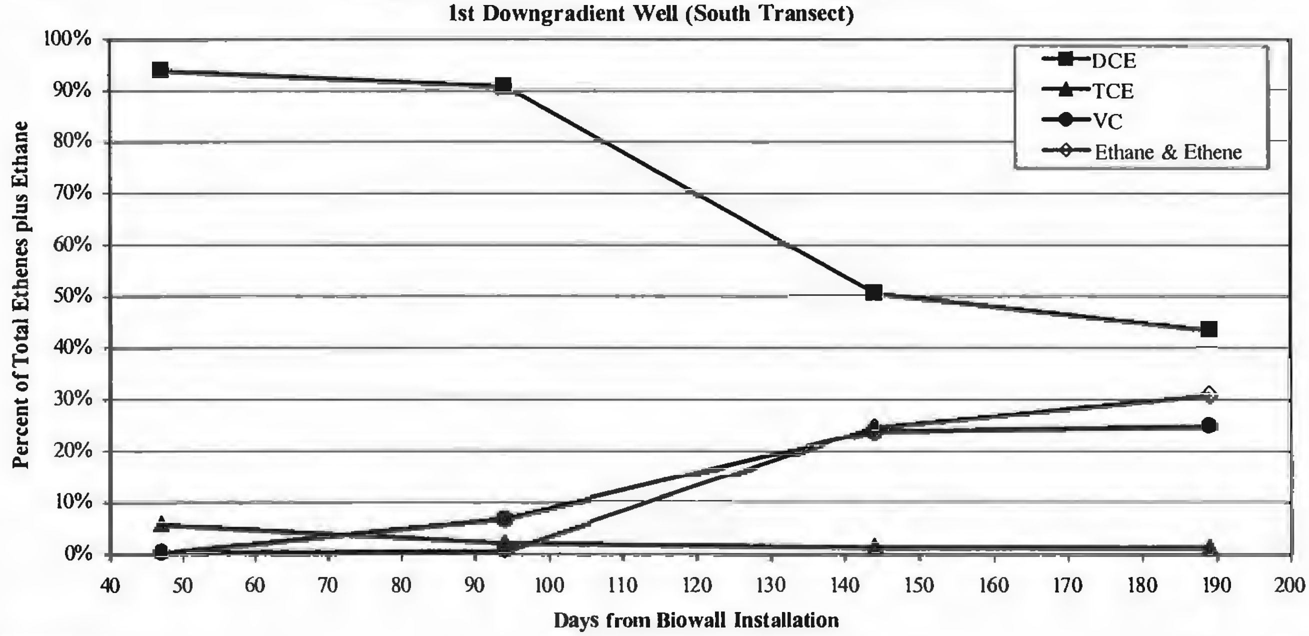


Figure 12
Ketone Concentrations along the North Transect - Round 2

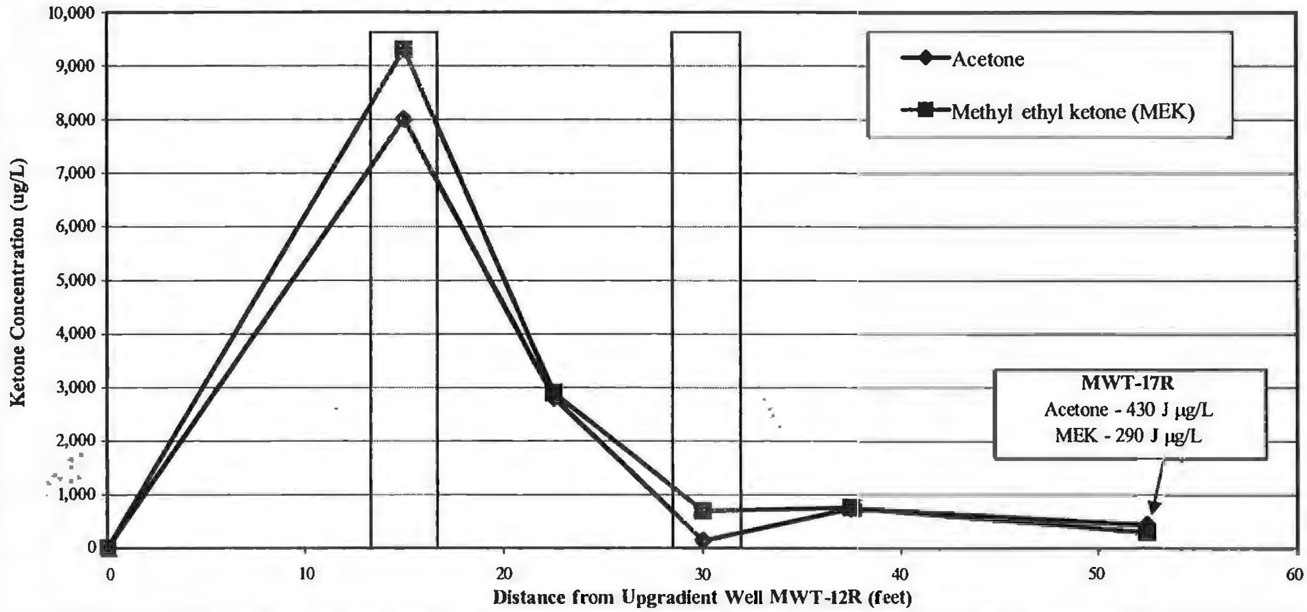


Figure 13
Ketone Concentrations along the North Transect - Round 4

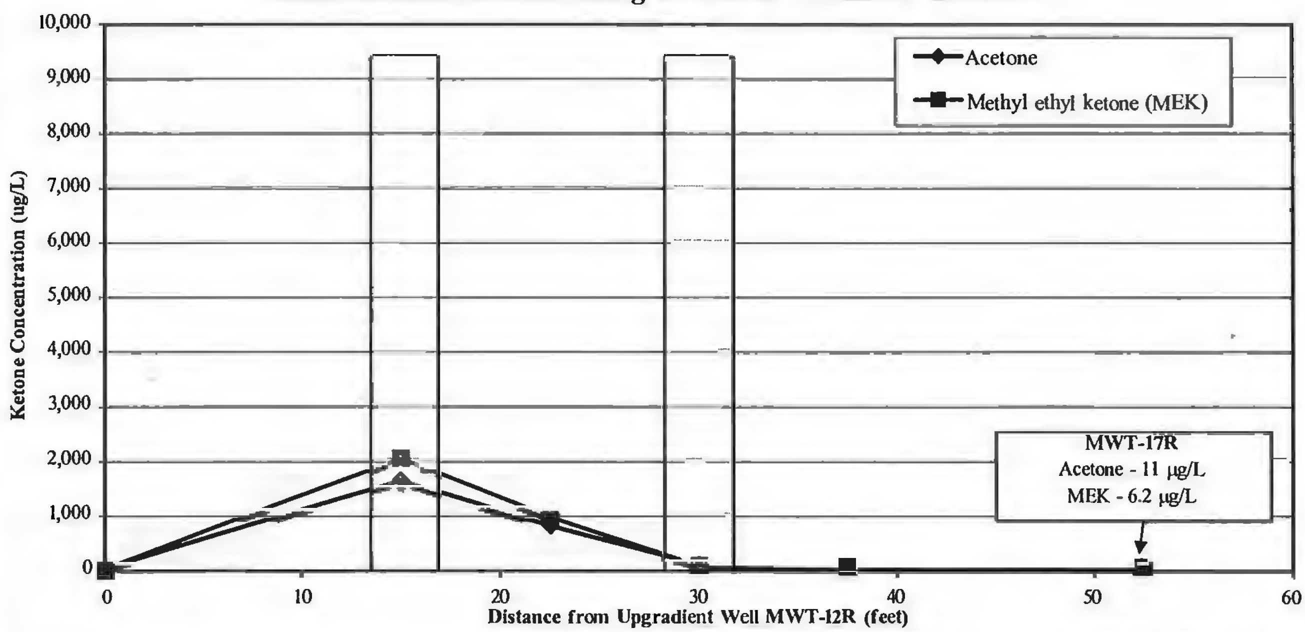


Figure 14
Ketone Concentrations along the South Transect - Round 2

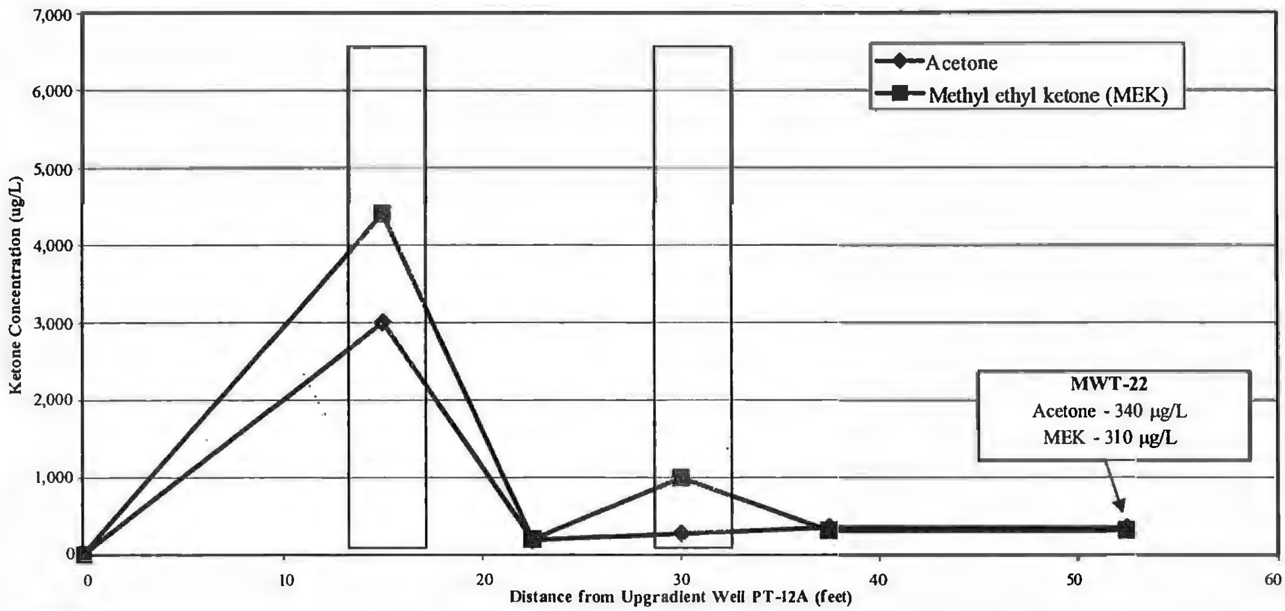
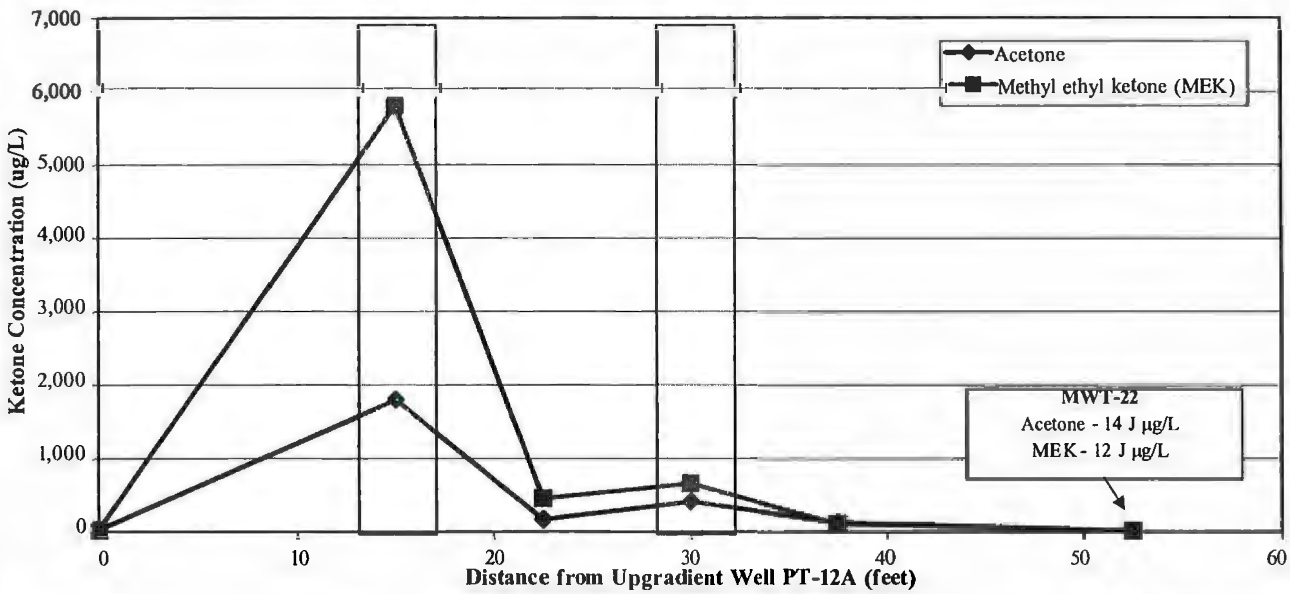


Figure 15
Ketone Concentrations along the South Transect - Round 4



ATTACHMENTS

Attachment A

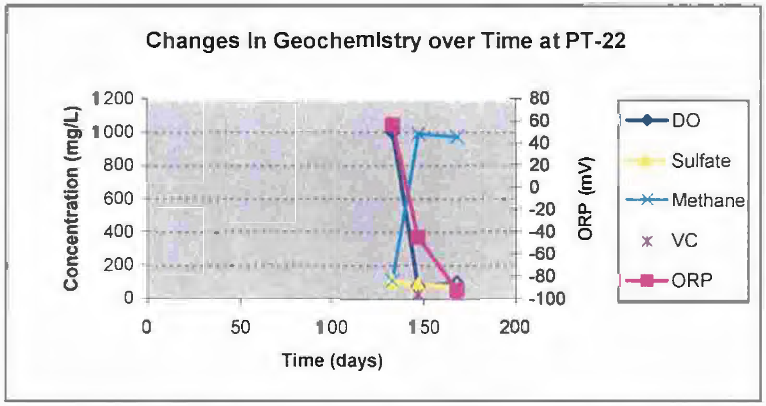
South Transect		Time from Installation (days)	DO	ORP	Sulfate	Iron	Mn	Methane	Ethane	Ethene	VC	TOC
MWT-22	22-Jul-05	0										
(22.5' downgradient)	2-Sep-05	42	0.45	-180	278	4.73	22	1300	1.7	3.4	2.4 U	361
	5-Oct-05	75	1.28	-228	296	2.68	6.1	1900	1.2	3.5	170	33.2
	15-Dec-05	146	0.04	-206	282	2.27	0.7	1900	1.2	95	140	34.5
	6-Jan-06	168	0.15	-104	370	2.3	6.1	2300	1.2	93	140 D	35.5

MWT-22 located 22.5 feet from biowall
Detection of anaerobic geochemical indicators occurred by 42 days.
Indicates minimum seepage velocity of approximately 0.54 ft/day, or 196 ft/year.

North Transect		Time from Installation (days)	DO	ORP	Sulfate	Iron	Mn	Methane	Ethane	Ethene	VC	TOC
MWT-17R	22-Jul-05	0										
(22.5' downgradient)	2-Sep-05	42	1.25	60	408	0	0.1	1.1	0.085	0.21	0.24 U	9.3
	5-Oct-05	75	0	-27	80.5	0.2	5.2	1000	0.049	0.58	19	111
	15-Dec-05	146	0	-126	43.8	0.8	3.3	4700	0.38	42	42	63.8
	6-Jan-06	168	0.29	-156	58.5	3.30*	15.2	7300	1.4	51	60	29.8

MWT-17R located 22.5 feet from biowall
Detection of anaerobic geochemical indicators occurred by 75 days.
Indicates minimum seepage velocity of approximately 0.3 ft/day, or 110 ft/year.

PT-22		Time from Installation (days)	DO x1000	ORP	Sulfate	Iron	Mn	Methane	Ethane	Ethene	VC	TOC
PT-22	22-Jul-05	0										
(150' Downgradient)	2-Dec-05	133	1000.0	57	110	4	1.4	110	0.017	10		7.8
	16-Dec-05	147	80	-44	88.8	0.1	0.8	990	0.14	45	30	13.4
	6-Jan-06	168	100	-91	78.3	0.17	1.5	970	0.3	30	26	6.9



PT-22 located 150 feet from biowall
Detection of anaerobic geochemical indicators by 150 days.
Indicates seepage velocity of approximately 1 ft/day, or 365 ft/year.

Attachment B

Table B.1 Contaminant Distribution and Mass Flux North Transect - January 2006

NOTE: Shaded boxes are user input.

1. Treatment Zone Physical Dimensions

	Values	Range	Units
Length (Perpendicular to predominant groundwater flow direction)	75	1-10,000	feet
Width (Parallel to predominant groundwater flow)	30	1-1,000	feet
Saturated Thickness	6	1-100	feet
Treatment Zone Cross Sectional Area	450	--	ft^2
Treatment Zone Volume	13,500	--	ft^3
Treatment Zone Total Pore Volume (total volume x total porosity)	25,252	--	gallons
Treatment Zone Effective Groundwater Volume (total volume x effective porosity)	303,021	--	gallons
Period of Performance	1	--	per year

2. Treatment Zone Hydrogeologic Properties

	Values	Range	Units
Total Porosity	0.25	.05-50	
Effective Porosity	3	.05-50	
Average Aquifer Hydraulic Conductivity	14	.01-1000	ft/day
Average Hydraulic Gradient	0.06	0.1-0.0001	ft/ft
Average Groundwater Seepage Velocity through the Treatment Zone	0.28	--	ft/day
Average Groundwater Seepage Velocity through the Treatment Zone	102.2	--	ft/yr
Average Groundwater Flux through the Treatment Zone	1,032,292	--	gallons/year
Soil Bulk Density	1.69	1.4-2.0	gm/cm^3
Soil Fraction Organic Carbon (foc)	0.02	0.0001-0.1	

3. Initial Distribution of Mass in the Treatment Zone (one total pore volume)

Concentrations for Well MWT-12R

A. Dissolved Contaminants

A. Dissolved Contaminants	Concentration (mg/L)	Mass (lb)
Tetrachloroethene (PCE)	0.000	0.000
Trichloroethene (TCE)	0.540	0.114
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.669	0.141
Vinyl Chloride (VC)	0.067	0.014
Carbon Tetrachloride (CT)	0.000	0.000
Trichloromethane (or chloroform) (CF)	0.000	0.000
Dichloromethane (or methylene chloride) (MC)	0.000	0.000
Chloromethane	0.000	0.000
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	0.000
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	0.000
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	0.000
Chloroethane	0.000	0.000

0.269 lbs dissoved in gw

B. Sorbed Contaminants

B. Sorbed Contaminants (Soil Concentration= Koc x foc x Cgw)	Koc (mL/g)	Soil Conc. (mg/kg)	Mass (lb)
Tetrachloroethene (PCE)	263	0.00	0.000
Trichloroethene (TCE)	107	1.16	1.646
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	45	0.60	0.858
Vinyl Chloride (VC)	3.0	0.00	0.006
Carbon Tetrachloride (CT)	224	0.00	0.000
Trichloromethane (or chloroform) (CF)	63	0.00	0.000
Dichloromethane (or methylene chloride) (MC)	28	0.00	0.000
Chloromethane	25	0.00	0.000
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	117	0.00	0.000
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	105	0.00	0.000
Dichloroethane (1,1-DCA and 1,2-DCA)	30	0.00	0.000
Chloroethane	3	0.00	0.000

2.510 lbs sorbed in soil

4. Treatment Cell Dissolved Contaminant Flux (per year)

A. Soluble Contaminant Flux

A. Soluble Contaminant Flux	Flux In (MWT-12R) Concentration (mg/L)	Mass (lb)	Flux Out (MWT-15) Concentration (mg/L)	Mass (lb)	Percent Reduction in Mass — Percent Reduction
Tetrachloroethene (PCE)	0.000	0.000	0.000	0.000	
Trichloroethene (TCE)	0.540	4.652	0.000	0.000	100.00%
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.669	5.765	0.005	0.046	99.21%
Vinyl Chloride (VC)	0.067	0.577	0.005	0.043	92.54%
Carbon Tetrachloride (CT)	0.000	0.000	0.000	0.000	
Trichloromethane (or chloroform) (CF)	0.000	0.000	0.000	0.000	
Dichloromethane (or methylene chloride) (MC)	0.000	0.000	0.000	0.000	
Chloromethane	0.000	0.000	0.000	0.000	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	0.000	0.000	0.000	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	0.000	0.000	0.000	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	0.000	0.000	0.000	
Chloroethane	0.000	0.000	0.000	0.000	
TOTAL MASS		10.99		0.09	99.2%

Attachment B

Table B.2 Contaminant Distribution and Mass Flux South Transect - January 2006

NOTE: Shaded boxes are user input.

1. Treatment Zone Physical Dimensions

	Values	Range	Units
Length (Perpendicular to predominant groundwater flow direction)	75	1-10,000	feet
Width (Parallel to predominant groundwater flow)	30	1-1,000	feet
Saturated Thickness	6	1-100	feet
Treatment Zone Cross Sectional Area	450	--	ft^2
Treatment Zone Volume	13,500	--	ft^3
Treatment Zone Total Pore Volume (total volume x total porosity)	25,252	--	gallons
Treatment Zone Effective Groundwater Volume (total volume x effective porosity)	15,151	--	gallons
Period of Performance	1	--	per year

2. Treatment Zone Hydrogeologic Properties

	Values	Range	Units
Total Porosity	0.25	.05-50	
Effective Porosity	0.15	.05-50	
Average Aquifer Hydraulic Conductivity	4.1	.01-1000	ft/day
Average Hydraulic Gradient	0.02	0.1-0.0001	ft/ft
Average Groundwater Seepage Velocity through the Treatment Zone	0.55	--	ft/day
Average Groundwater Seepage Velocity through the Treatment Zone	199.5	--	ft/yr
Average Groundwater Flux through the Treatment Zone	100,771	--	gallons/design life
Soil Bulk Density	1.69	1.4-2.0	gm/cm^3
Soil Fraction Organic Carbon (foe)	0.02	0.0001-0.1	

3. Initial Distribution of Mass in the Treatment Zone (one total pore volume)

Concentrations are for Well PT-12A

A. Dissolved Contaminants

	Concentration (mg/L)	Mass (lb)
Tetrachloroethene (PCE)	0.000	0.000
Trichloroethene (TCE)	0.530	0.112
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.406	0.085
Vinyl Chloride (VC)	0.019	0.004
Carbon Tetrachloride (CT)	0.000	0.000
Trichloromethane (or chloroform) (CF)	0.000	0.000
Dichloromethane (or methylene chloride) (MC)	0.000	0.000
Chloromethane	0.000	0.000
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	0.000
Trichloroethane (1,1,1-TCAand 1,1,2-TCA)	0.000	0.000
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	0.000
Chloroethane	0.000	0.000

0.201 lbs in dissolved phase

B. Sorbed Contaminants
(Soil Concentration = Koc x foc x Cgw)

	Koc (mL/g)	Soil Conc. (mg/kg)	Mass (lb)
Tetrachloroethene (PCE)	263	0.00	0.000
Trichloroethene (TCE)	107	1.13	1.616
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	45	0.37	0.520
Vinyl Chloride (VC)	3.0	0.00	0.002
Carbon Tetrachloride (CT)	224	0.00	0.000
Trichloromethane (or chloroform) (CF)	63	0.00	0.000
Dichloromethane (or methylene chloride) (MC)	28	0.00	0.000
Chloromethane	25	0.00	0.000
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	117	0.00	0.000
Trichloroethane (1,1,1-TCAand 1,1,2-TCA)	105	0.00	0.000
Dichloroethane (1,1-DCA and 1,2-DCA)	30	0.00	0.000
Chloroethane	3	0.00	0.000

2.137 lbs sorbed

4. Treatment Cell Dissolved Contaminant Flux (per year)

A. Soluble Contaminant Flux

	Flux In (PT-12A) Concentration (mg/L)	Flux In (PT-12A) Mass (lb)	Flux Out (MWT-20) Concentration (mg/L)	Flux Out (MWT-20) Mass (lb)	Percent Reduction in Mass: Percent Reduction
Tetrachloroethene (PCE)	0.000	0.000	0.000	0.000	
Trichloroethene (TCE)	0.530	0.446	0.000	0.000	100.00%
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.406	0.341	0.010	0.009	97.49%
Vinyl Chloride (VC)	0.019	0.016	0.009	0.008	52.11%
Carbon Tetrachloride (CT)	0.000	0.000	0.000	0.000	
Trichloromethane (or chloroform) (CF)	0.000	0.000	0.000	0.000	
Dichloromethane (or methylene chloride) (MC)	0.000	0.000	0.000	0.000	
Chloromethane	0.000	0.000	0.000	0.000	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	0.000	0.000	0.000	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	0.000	0.000	0.000	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	0.000	0.000	0.000	
Chloroethane	0.000	0.000	0.000	0.000	
TOTAL MASS		0.80		0.02	98.0%

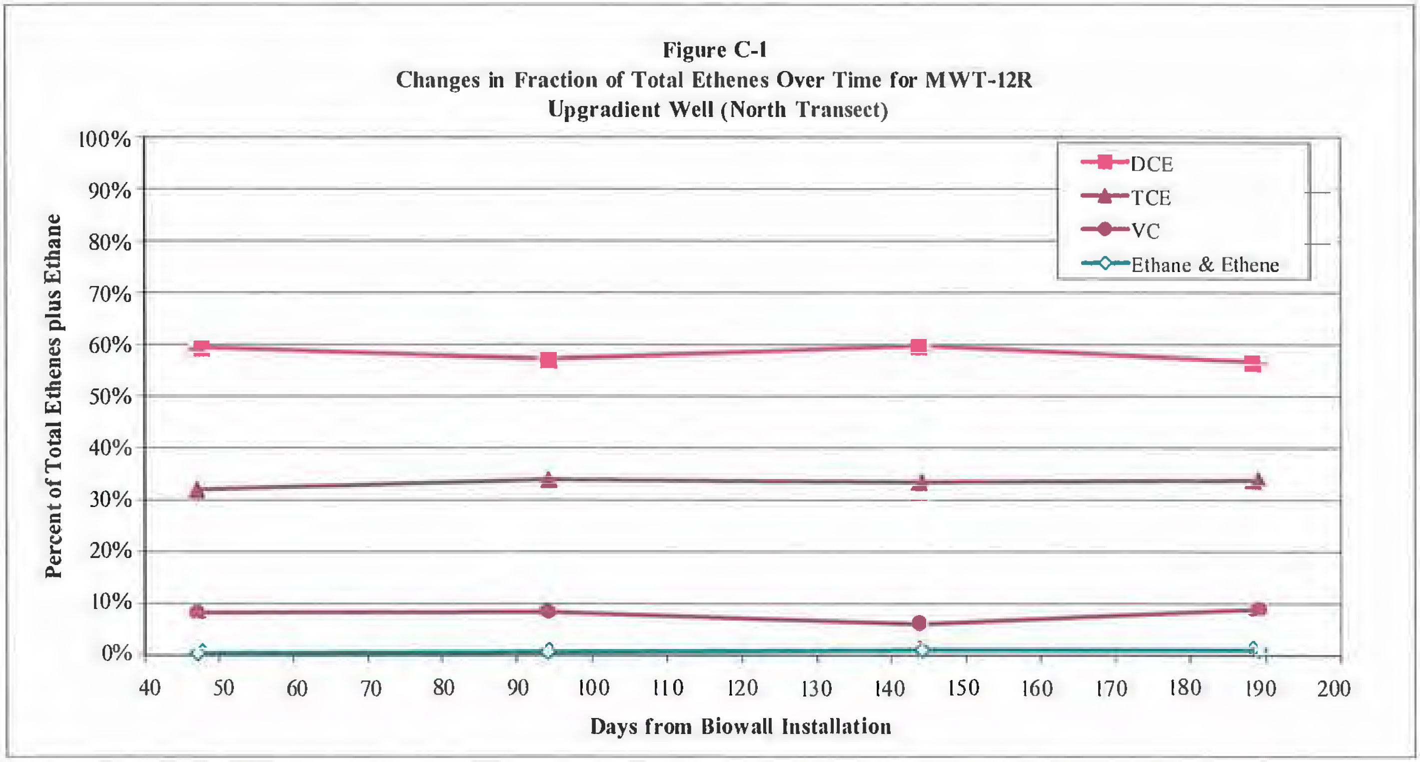


Figure C-1
Changes in Fraction of Total Ethenes Over Time for MWT-12R
Upgradient Well (North Transect)
Percent of Total Ethenes plus Ethane
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
Days from Biowall Installation
DCE
TCE
VC
Ethane & Ethene

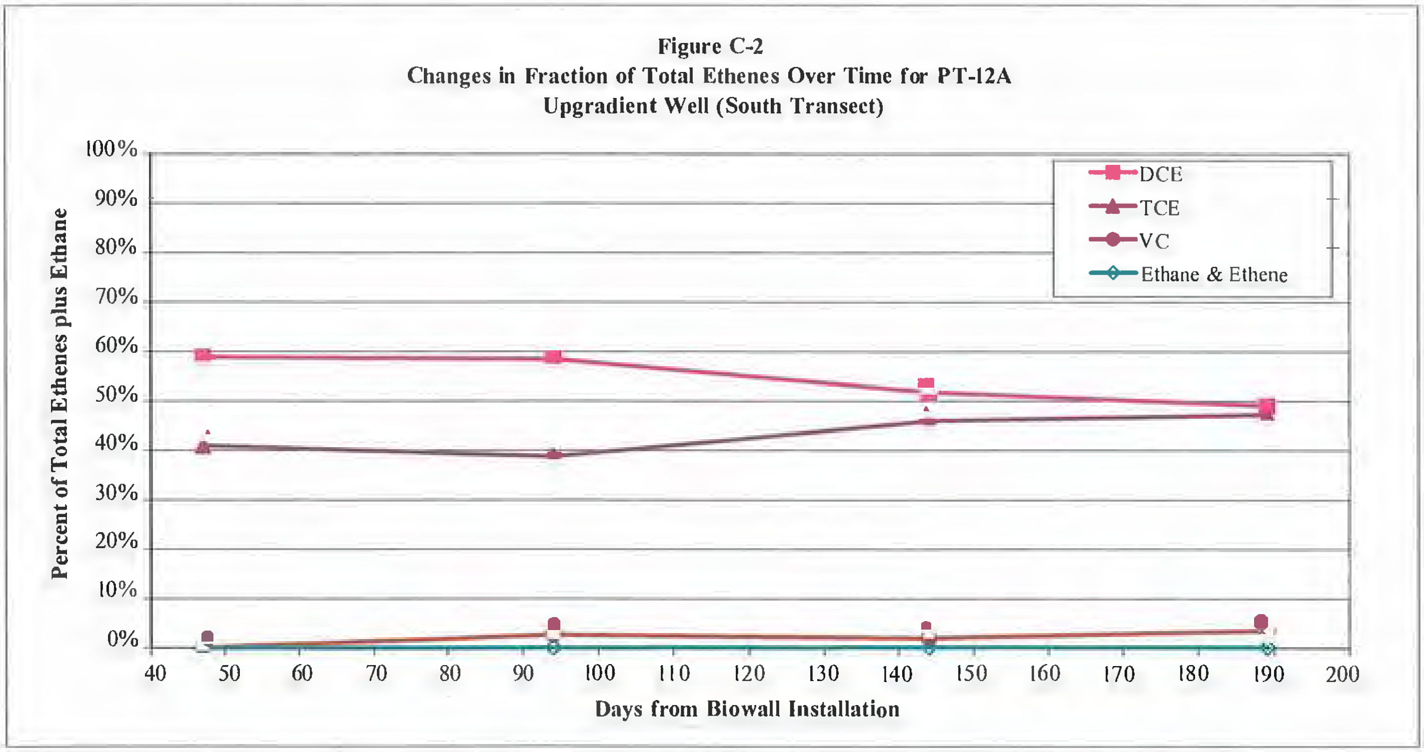


Figure C-2
Changes in Fraction of Total Ethenes Over Time for PT-12A
Upgradient Well (South Transect)
Percent of Total Ethenes plus Ethane
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
Days from Biowall Installation
DCE
TCE
VC
Ethane & Ethene

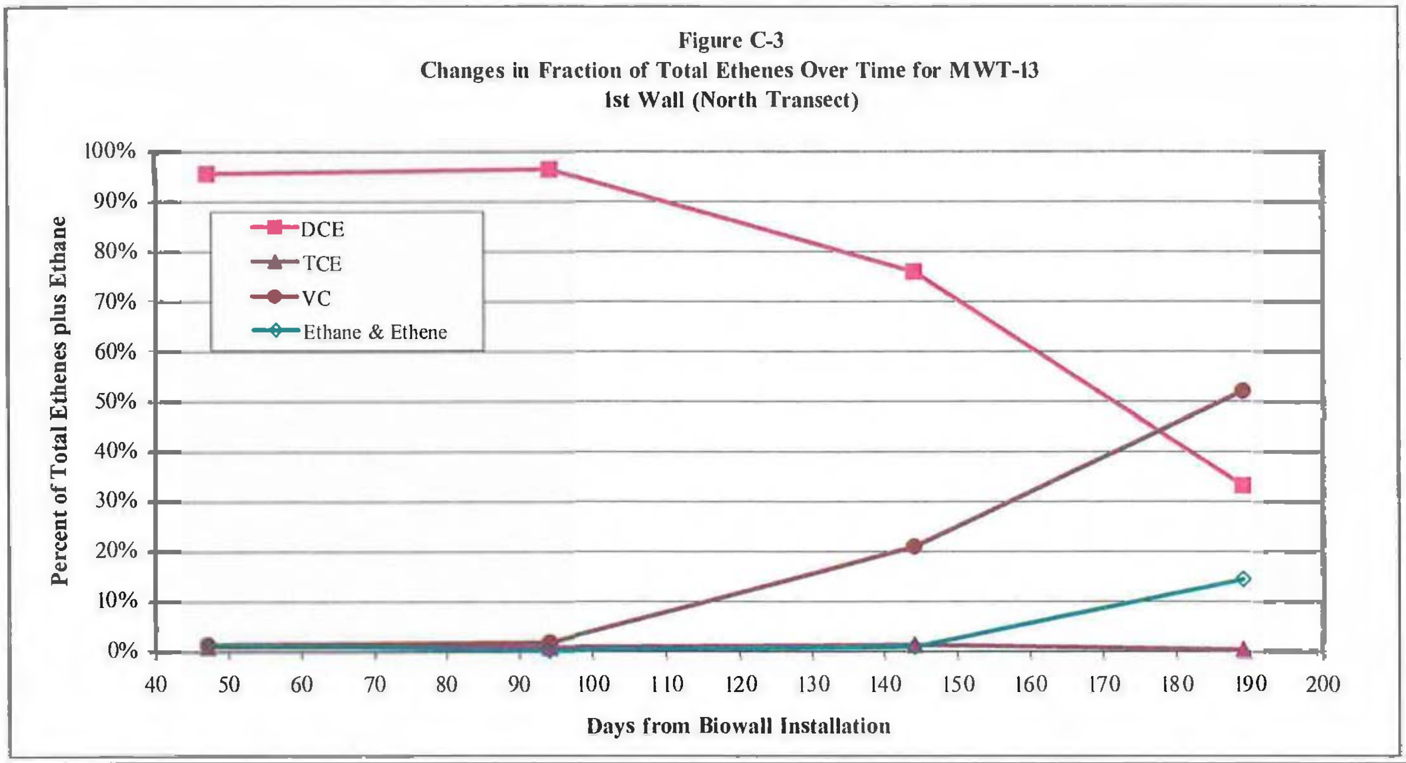


Figure C-3
Changes in Fraction of Total Ethenes Over Time for MWT-13
1st Wall (North Transect)
Percent of Total Ethenes plus Ethane
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
Days from Biowall Installation
DCE
TCE
VC
Ethane & Ethene

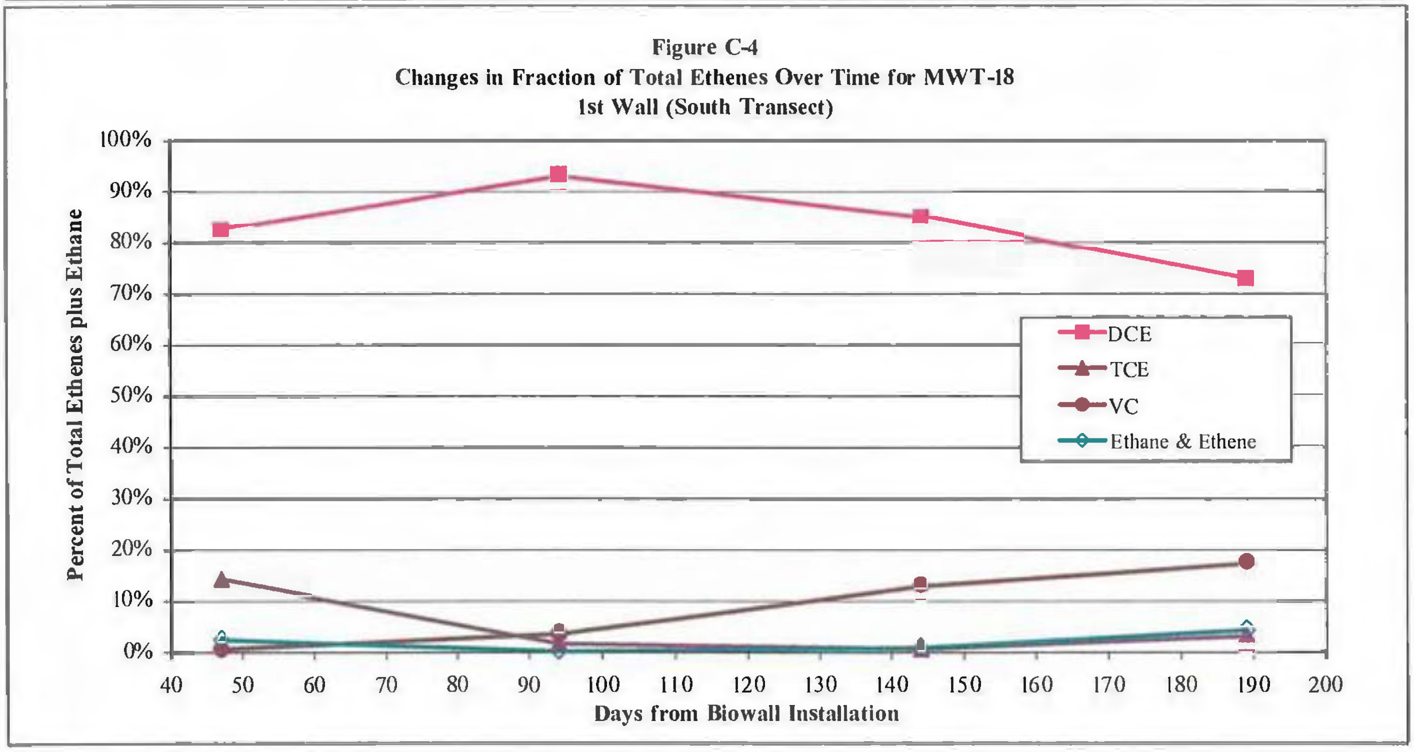


Figure C-4
Changes in Fraction of Total Ethenes Over Time for MWT-18
1st Wall (South Transect)
Percent of Total Ethenes plus Ethane
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
Days from Biowall Installation
DCE
TCE
VC
Ethane & Ethene

Figure C-5
Changes in Fraction of Total Ethenes Over Time for MWT-14
Between Walls (North Transect)

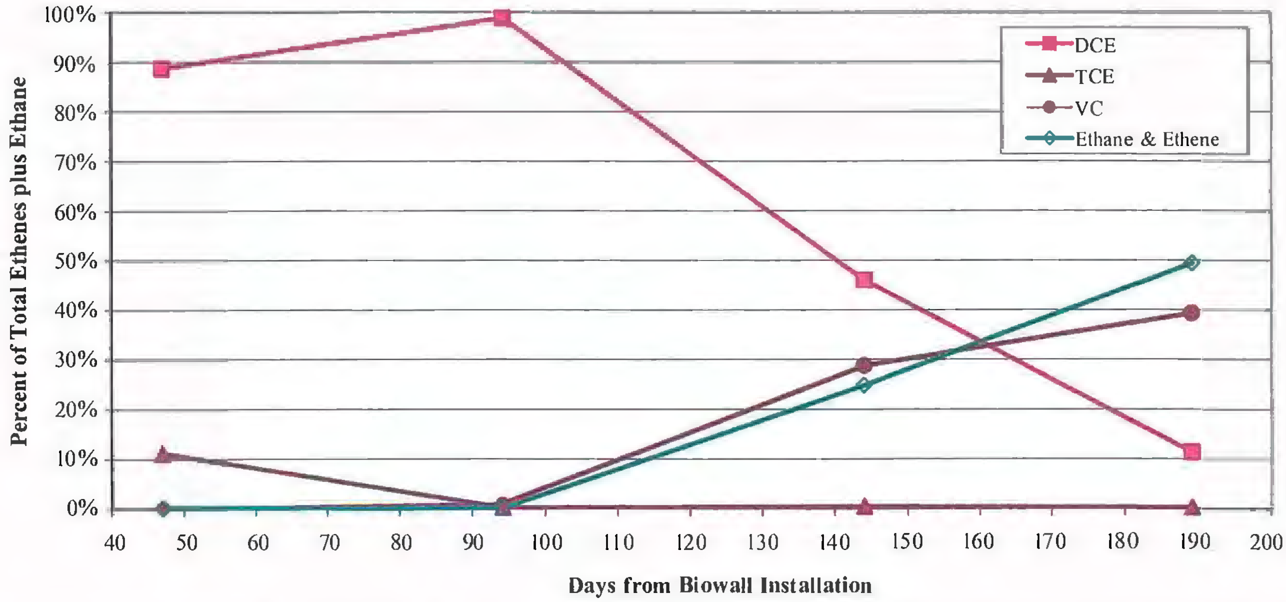


Figure C-6
Changes in Fraction of Total Ethenes Over Time for MWT-19
Between Walls (South Transect)

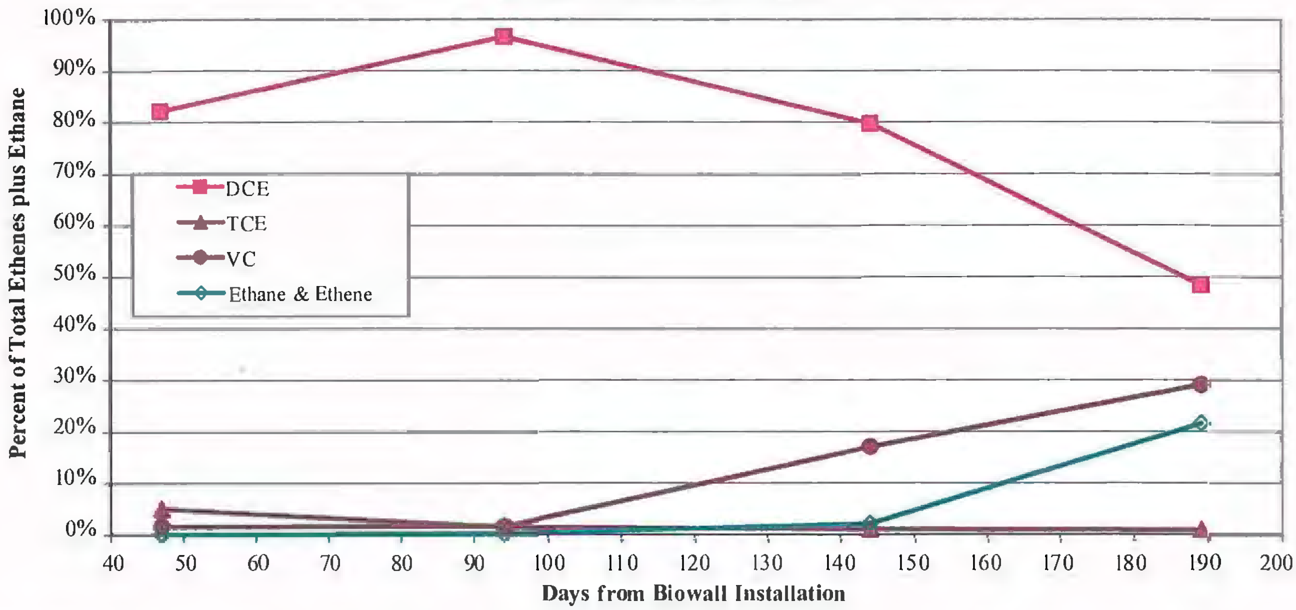


Figure C-7
Changes in Fraction of Total Ethenes Over Time for MWT-15
2nd Wall (North Transect)

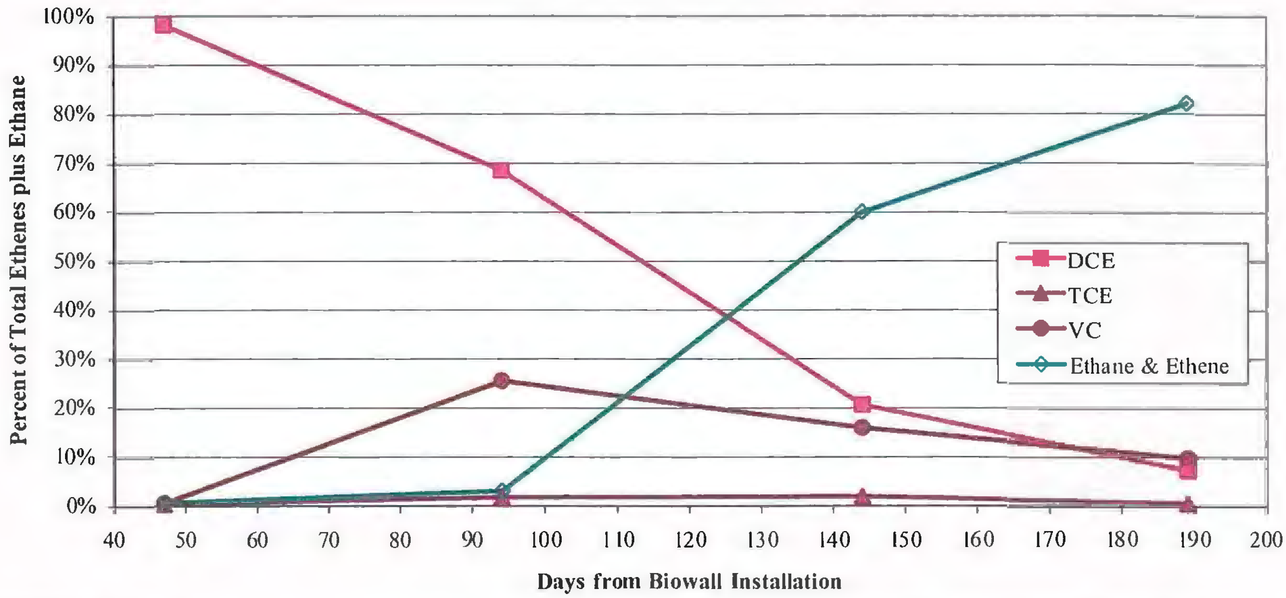


Figure C-8
Changes in Fraction of Total Ethenes Over Time for MWT-20
2nd Wall (South Transect)

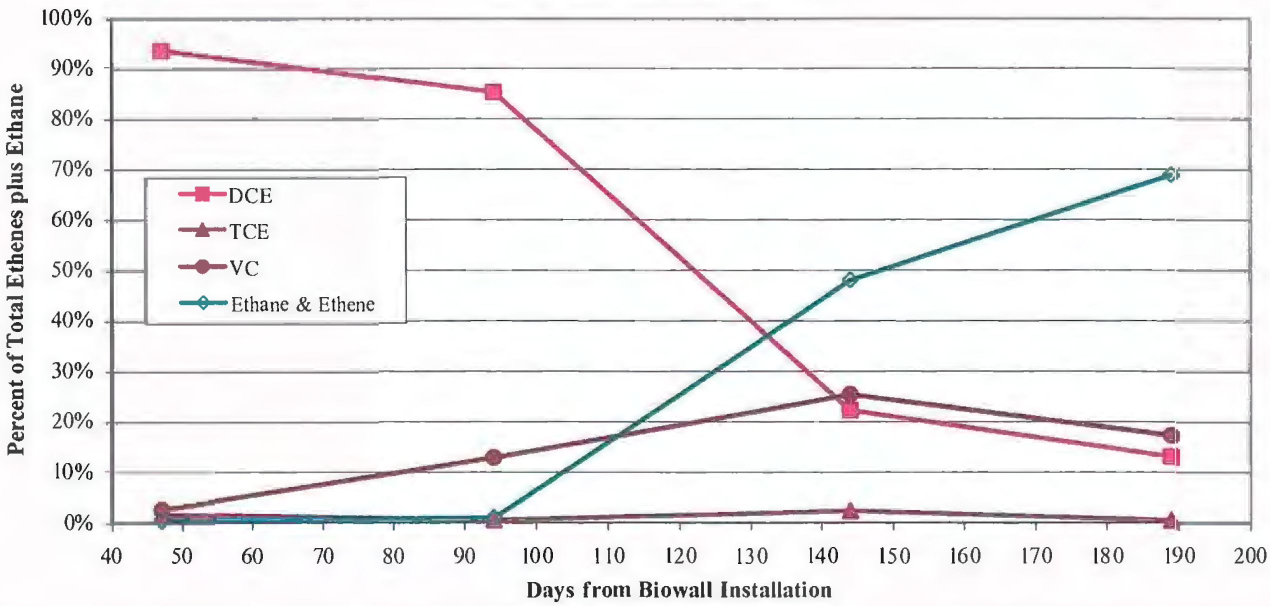


Figure C-9
Changes in Fraction of Total Ethenes Over Time for MWT-16
1st Downgradient Well (North Transect)

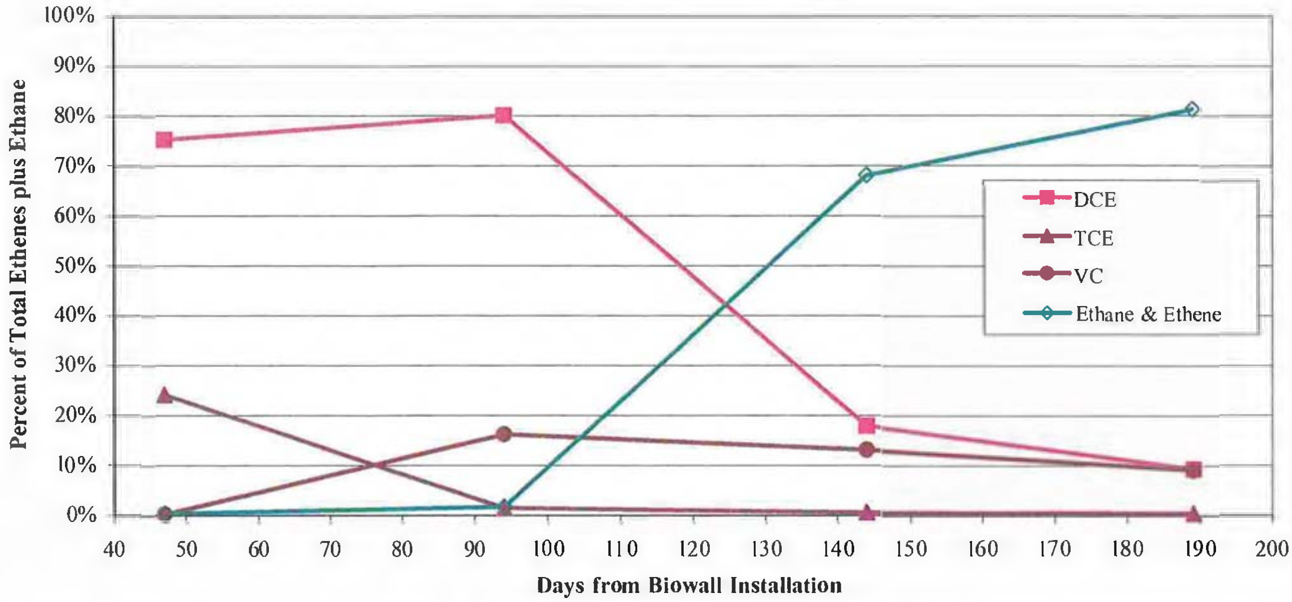


Figure C-10
Changes in Fraction of Total Ethenes Over Time for MWT-21
1st Downgradient Well (South Transect)

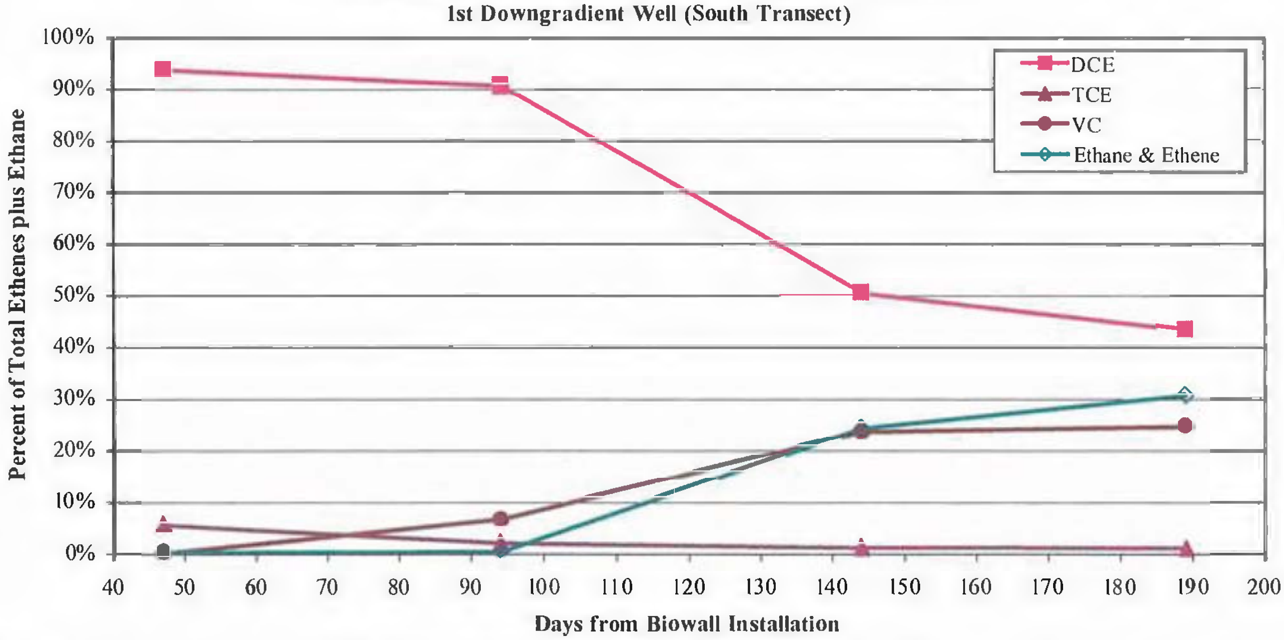


Figure C-11
Changes in Fraction of Total Ethenes Over Time for MWT-17R
2nd Downgradient Well (North Transect)

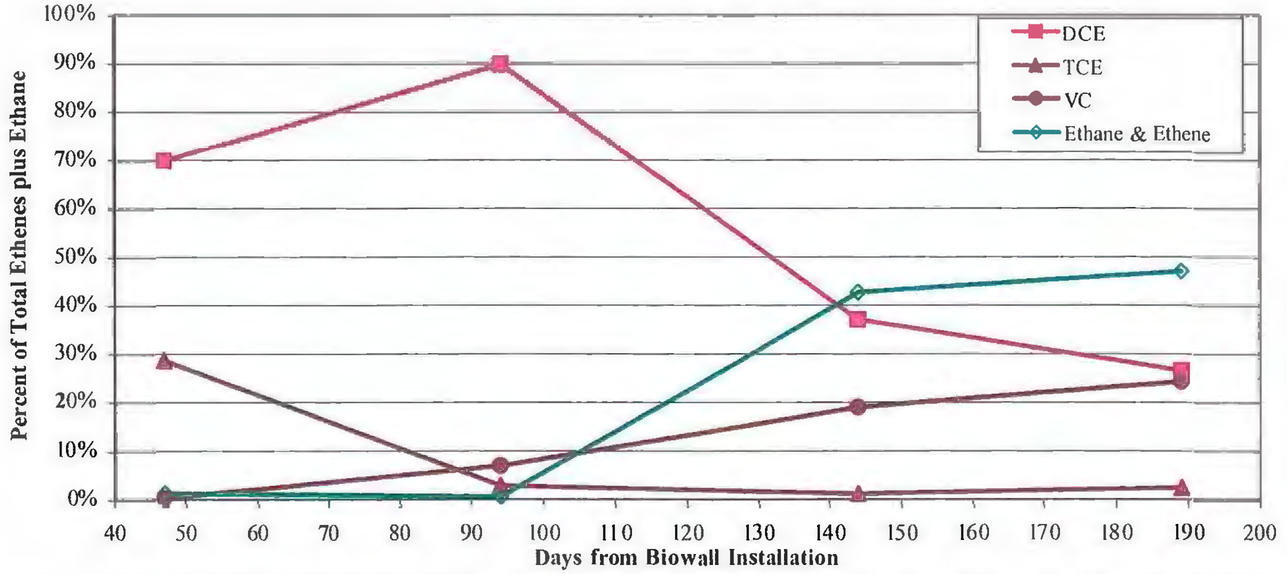
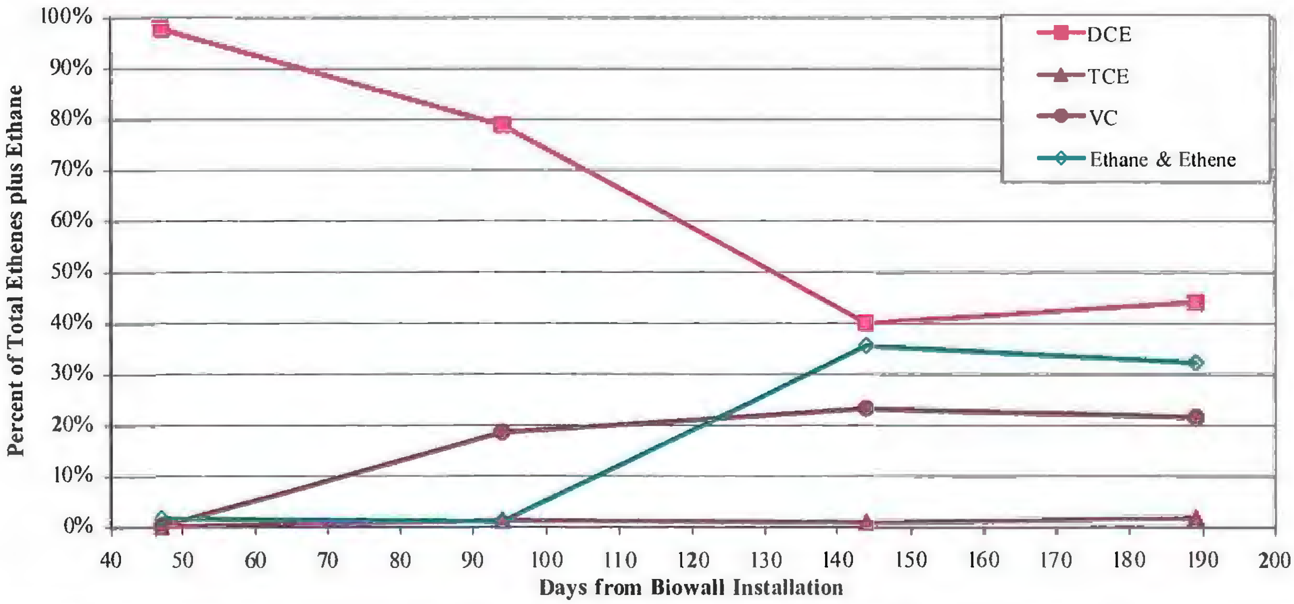


Figure C-12
Changes in Fraction of Total Ethenes Over Time from MWT-22
2nd Downgradient Well (South Transect)



ATTACHMENT D-1
Detected VOCs* Round 1 of Biowall Treatability Study

Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

Facility									ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID									MWT-12R	MWT-12R	MWT-13	MWT-14	MWT-15
Matrix									GW	GW	GW	GW	GW
Sample ID									ALBW20013	ALBW20012	ALBW20011	ALBW20010	ALBW20009
Sample Depth to Top of Sample									0	0	0	0	0
Sample Depth to Bottom of Sample									0	0	0	0	0
Sample Date									9/12/2005	9/12/2005	9/12/2005	9/9/2005	9/9/2005
QC Code									DU	SA	SA	SA	SA
Study ID									BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS
Round									1	1	1	1	1
Parameter	**Units**	**Maximum**	**Frequency**	**Criteria**	**Criteria Source**	**No. Exceed**	**No. Detect**	**No. of Analyses**	**Value (Q)**	**Value (Q)**	**Value (Q)**	**Value (Q)**	**Value (Q)**
1,1-Dichloroethene	UG/L	2	8%	5	GA	0	1	13	80 U	80 U	250 U	50 U	50 U
1,2-Dichloroethane	UG/L	22	15%	0.6	GA	2	2	13	80 U	80 U	250 U	50 U	50 U
Acetone	UG/L	3400	69%			0	9	13	80 U	80 U	1600	660	3400
Cis-1,2-Dichloroethene	UG/L	1300	100%	5	GA	13	13	13	960	970	320	1000	170
Methyl butyl ketone	UG/L	27	15%			0	2	13	80 U	80 U	250 U	50 U	50 U
Methyl ethyl ketone	UG/L	2700	69%			0	9	13	80 UJ	80 U	2700	910	820
Trans-1,2-Dichloroethene	UG/L	13	8%	5	GA	1	1	13	80 U	80 U	250 U	50 U	50 U
Trichloroethene	UG/L	860	69%	5	GA	9	9	13	730	680	250 U	170	50 U
Vinyl chloride	UG/L	95	23%	2	GA	3	3	13	95	77 J	250 U	50 U	50 U

ATTACHMENT D-1
Detected VOCs - Round 1 of Biowall Treatability Study

Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

Facility									ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID									MWT-16	MWT-17R	MWT-18	MWT-19	MWT-20
Matrix									GW	GW	GW	GW	GW
Sample ID									ALBW20008	ALBW20007	ALBW20005	ALBW20004	ALBW20003
Sample Depth to Top of Sample									0	0	0	0	0
Sample Depth to Bottom of Sample									0	0	0	0	0
Sample Date									9/9/2005	9/9/2005	9/8/2005	9/8/2005	9/7/2005
QC Code									SA	SA	SA	SA	SA
Study ID									BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS
Round									1	1	1	1	1
Parameter	**Units**	**Maximum**	**Frequency**	**Criteria**	**Criteria Source**	**No. Exceed**	**No. Detect**	**No. of Analyses**	Value (Q)	Value (Q)	Value (Q)	Value (Q)	Value (Q)
1,1-Dichloroethene	UG/L	2	8%	5	GA	0	1	13	20 U	10 U	50 U	2 J	250 U
1,2-Dichloroethane	UG/L	22	15%	0.6	GA	2	2	13	22	22	50 U	10 U	250 U
Acetone	UG/L	3400	69%			0	9	13	270	10 U	1200 J	370	3200
Cis-1,2-Dichloroethene	UG/L	1300	100%	5	GA	13	13	13	160	59	120	1300	160 J
Methyl butyl ketone	UG/L	27	15%			0	2	13	20 U	10 U	27 J	4 J	250 U
Methyl ethyl ketone	UG/L	2700	69%			0	9	13	120	10 U	2500 J	600	1700
Trans-1,2-Dichloroethene	UG/L	13	8%	5	GA	1	1	13	20 U	10 U	50 U	13	250 U
Trichloroethene	UG/L	860	69%	5	GA	9	9	13	70	33	28 J	110	250 U
Vinyl chloride	UG/L	95	23%	2	GA	3	3	13	20 U	10 U	50 U	17	250 U

ATTACHMENT D-1
Detected VOCs - Round 1 of Biowall Treatability Study

Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

Facility									ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID									MWT-21	MWT-22	PT-12A
Matrix									GW	GW	GW
Sample ID									ALBW20002	ALBW20001	ALBW20006
Sample Depth to Top of Sample									0	0	0
Sample Depth to Bottom of Sample									0	0	0
Sample Date									9/7/2005	9/7/2005	9/9/2005
QC Code									SA	SA	SA
Study ID									BIOWALL TS	BIOWALL TS	BIOWALL TS
Round									1	1	1
Parameter	Units	Maximum	Frequency	Criteria	Criteria Source	No. Exceed	No. Detect	No. of Analyses	Value (Q)	Value (Q)	Value (Q)
1,1-Dichloroethene	UG/L	2	8%	5	GA	0	1	13	100 U	100 U	50 U
1,2-Dichloroethane	UG/L	22	15%	0.6	GA	2	2	13	100 U	100 U	50 U
Acetone	UG/L	3400	69%			0	9	13	250	440	50 U
Cis-1,2-Dichloroethene	UG/L	1300	100%	5	GA	13	13	13	1200	1000	910
Methyl butyl ketone	UG/L	27	15%			0	2	13	100 U	100 U	50 U
Methyl ethyl ketone	UG/L	2700	69%			0	9	13	270	480	50 U
Trans-1,2-Dichloroethene	UG/L	13	8%	5	GA	1	1	13	100 U	100 U	50 U
Trichloroethene	UG/L	860	69%	5	GA	9	9	13	98 J	100 U	860
Vinyl chloride	UG/L	95	23%	2	GA	3	3	13	100 U	100 U	50 U

ATTACHMENT D-2
Detected VOCs - Round 2 of Biowall Treatability Study

Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

Parameter	Units	Maximum	Frequency	Criteria	Criteria Source	No. Exceed	No. Detect	No. of Analyses	Value (Q)	Value (Q)	Value (Q)	Value (Q)	Value (Q)
Facility									ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID									MW-56	MWT-12R	MWT-12R	MWT-13	MWT-14
Matrix									GW	GW	GW	GW	GW
Sample ID									ALBW20026	ALBW20027	ALBW20025	ALBW20024	ALBW20023
Sample Depth to Top of Sample									0	0	0	0	0
Sample Depth to Bottom of Sample									0	0	0	0	0
Sample Date									10/26/2005	10/26/2005	10/26/2005	10/26/2005	10/25/2005
QC Code									SA	DU	SA	SA	SA
Study ID									BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS
Round									2	2	2	2	2
1,1-Dichloroethene	UG/L	2.8	29%	5	GA	0	4	14	1 U	2.6	2.8	20 U	10 U
1,2-Dichloroethane	UG/L	12	36%	0.6	GA	5	5	14	1 U	0.74 J	0.7 J	20 U	10 U
Acetone	UG/L	8000	93%			0	13	14	4.3 J	3 J	4.1 J	8000	2800
Benzene	UG/L	0.48	14%	1	GA	0	2	14	1 U	0.45 J	0.48 J	20 UJ	10 U
Cis-1,2-Dichloroethene	UG/L	1600	100%	5	GA	13	14	14	1.8	880	910	410	1600
Methyl butyl ketone	UG/L	34	21%			0	3	14	5 U	5 U	5 U	100 U	50 U
Methyl ethyl ketone	UG/L	9300	71%			0	10	14	5 U	5 U	5 U	9300	2900
Toluene	UG/L	15	21%	5	GA	1	3	14	1 U	1 U	1 U	20 UJ	10 U
Trans-1,2-Dichloroethene	UG/L	38	64%	5	GA	8	9	14	1 U	22	23	20 U	22
Trichloroethene	UG/L	740	57%	5	GA	8	8	14	1 U	710	740	20 U	10 U
Vinyl chloride	UG/L	170	79%	2	GA	11	11	14	1 U	82	87	20 U	10

ATTACHMENT D-2
Detected VOCs - Round 2 of Biowall Treatability Study

Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

Facility									ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID									MWT-15	MWT-16	MWT-17R	MWT-18	MWT-19
Matrix									GW	GW	GW	GW	GW
Sample ID									ALBW20022	ALBW20021	ALBW20020	ALBW20018	ALBW20017
Sample Depth to Top of Sample									0	0	0	0	0
Sample Depth to Bottom of Sample									0	0	0	0	0
Sample Date									10/25/2005	10/25/2005	10/24/2005	10/25/2005	10/25/2005
QC Code									SA	SA	SA	SA	SA
Study ID									BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS
Round									2	2	2	2	2
Parameter	**Units**	**Maximum**	**Frequency**	**Criteria**	**Criteria Source**	**No. Exceed**	**No. Detect**	**No. of Analyses**	**Value (Q)**	**Value (Q)**	**Value (Q)**	**Value (Q)**	**Value (Q)**
1,1-Dichloroethene	UG/L	2.8	29%	5	GA	0	4	14	20 U	20 U	1 U	20 U	5 U
1,2-Dichloroethane	UG/L	12	36%	0.6	GA	5	5	14	20 U	12 J	9.9	20 U	5 U
Acetone	UG/L	8000	93%			0	13	14	140	740	430 J	3000	190
Benzene	UG/L	0.48	14%	1	GA	0	2	14	20 UJ	20 UJ	1 U	20 UJ	5 U
Cis-1,2-Dichloroethene	UG/L	1600	100%	5	GA	13	14	14	140	380	380	190	1600
Methyl butyl ketone	UG/L	34	21%			0	3	14	100 U	100 U	3.6 J	100 U	25 U
Methyl ethyl ketone	UG/L	9300	71%			0	10	14	690	750	290 J	4400	200
Toluene	UG/L	15	21%	5	GA	1	3	14	20 UJ	20 UJ	1.1	20 UJ	5 U
Trans-1,2-Dichloroethene	UG/L	38	64%	5	GA	8	9	14	20 U	20 U	5.9	20 U	21
Trichloroethene	UG/L	740	57%	6	GA	8	8	14	20 U	9.5 J	16	20 U	33
Vinyl chloride	UG/L	170	79%	2	GA	11	11	14	36	51	19	20 U	18

ATTACHMENT D-2

Detected VOCs - Round 2 of Biowall Treatability Study

Ash Landfill Mulch Biowall

Seneca Army Depot, Romulus, New York

Facility									ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID									MWT-20	MWT-21	MWT-22	PT-12A
Matrix									GW	GW	GW	GW
Sample ID									ALBW20016	ALBW20015	ALBW20014	ALBW20019
Sample Depth to Top of Sample									0	0	0	0
Sample Depth to Bottom of Sample									0	0	0	0
Sample Date									10/24/2005	10/24/2005	10/26/2005	10/25/2005
QC Code									SA	SA	SA	SA
Study ID									BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS
Round									2	2	2	2
Parameter	Units	Maximum	Frequency	Criteria	Criteria Source	No. Exceed	No. Detect	No. of Analyses	Value (Q)	Value (Q)	Value (Q)	Value (Q)
1,1-Dichloroethene	UG/L	2.8	29%	5	GA	0	4	14	5 U	2.4 J	5 U	1.3
1,2-Dichloroethane	UG/L	12	36%	0.6	GA	5	5	14	5 U	0.61 J	5 U	1 U
Acetone	UG/L	8000	93%			0	13	14	270 J	350 J	340	5 U
Benzene	UG/L	0.48	14%	1	GA	0	2	14	5 U	1 U	5 U	1 U
Cis-1,2-Dichloroethene	UG/L	1600	100%	5	GA	13	14	14	160	1400	1100	800
Methyl butyl ketone	UG/L	34	21%			0	3	14	34	6	25 U	5 U
Methyl ethyl ketone	UG/L	9300	71%			0	10	14	990 J	310 J	310	5 U
Toluene	UG/L	15	21%	5	GA	1	3	14	15	4.8	5 U	1 U
Trans-1,2-Dichloroethene	UG/L	38	64%	5	GA	8	9	14	2.9 J	38	17	11
Trichloroethene	UG/L	740	57%	5	GA	8	8	14	5 U	45	25	730
Vinyl chloride	UG/L	170	79%	2	GA	11	11	14	16	69	170	24

ATTACHMENT D-3
Detected VOCs - Round 3 of Biowall Treatability Study

Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

Facility									ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID									MW-39	MWT-12R	MWT-13	MWT-14
Matrix									GW	GW	GW	GW
Sample ID									ALBW20028	ALBW20041	ALBW20040	ALBW20039
Sample Depth to Top of Sample									0	0	0	0
Sample Depth to Bottom of Sample									0	0	0	0
Sample Date									12/1/2005	12/16/2005	12/16/2005	12/15/2005
QC Code									SA	SA	SA	SA
Study ID									BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS
Round									3	3	3	3
Parameter	**Units**	**Maximum**	**Frequency**	**Criteria**	**Criteria Source**	**No. Exceed**	**No. Detect**	**No. of Analyses**	**Value (Q)**	**Value (Q)**	**Value (Q)**	**Value (Q)**
1,1-Dichloroethene	UG/L	2.9	20%	5	GA	0	3	15		2.9	10 U	10 U
1,2,4-Trichlorobenzene	UG/L	3.8	7%	5	GA	0	1	15		1 U	10 U	10 U
1,2-Dichloroethane	UG/L	6.8	27%	0.6	GA	4	4	15		1 U	10 U	10 U
Acetone	UG/L	4900	80%			0	12	15		3.8 J	4900	2300
Benzene	UG/L	2.9	13%	1	GA	1	2	15		0.5 J	10 U	10 U
Cis-1,2-Dichloroethene	UG/L	1000	100%	5	GA	15	15	15		980	220	550
Methyl butyl ketone	UG/L	62	20%			0	3	15		5 U	62	36 J
Methyl ethyl ketone	UG/L	7600	67%			0	10	15		5 U	6000	2800
Toluene	UG/L	26	40%	5	GA	3	6	15		1 U	10 U	10 U
Trans-1,2-Dichloroethene	UG/L	22	87%	5	GA	7	13	15		21	10 U	15
Trichloroethene	UG/L	760	67%	5	GA	8	10	15		760	10 U	10 U
Vinyl chloride	UG/L	230	100%	2	GA	15	15	15		64	41	230

ATTACHMENT D-3
Detected VOCs - Round 3 of Biowall Treatability Study

Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

Parameter	Units	Maximum	Frequency	Criteria	Criteria Source	No. Exceed	No. Detect	No. of Analyses	Value (Q)	Value (Q)	Value (Q)	Value (Q)
Facility									ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID									MWT-15	MWT-16	MWT-17R	MWT-18
Matrix									GW	GW	GW	GW
Sample ID									ALBW20038	ALBW20037	ALBW20036	ALBW20034
Sample Depth to Top of Sample									0	0	0	0
Sample Depth to Bottom of Sample									0	0	0	0
Sample Date									12/14/2005	12/13/2005	12/12/2005	12/14/2005
QC Code									SA	SA	SA	SA
Study ID									BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS
Round									3	3	3	3
1,1-Dichloroethene	UG/L	2.9	20%	5	GA	0	3	15	5 U	5 U	5 U	5 U
1,2,4-Trichlorobenzene	UG/L	3.8	7%	5	GA	0	1	15	5 U	5 U	5 U	3.8 J
1,2-Dichloroethane	UG/L	6.8	27%	0.6	GA	4	4	15	5 U	6.8	6.6	5 U
Acetone	UG/L	4900	80%			0	12	15	130	85	79	4700 J
Benzene	UG/L	2.9	13%	1	GA	1	2	15	5 U	5 U	5 U	2.9 J
Cis-1,2-Dichloroethene	UG/L	1000	100%	5	GA	15	15	15	15	58	120	230
Methyl butyl ketone	UG/L	62	20%			0	3	15	25 U	25 U	25 U	49
Methyl ethyl ketone	UG/L	7600	67%			0	10	15	140	210	180	7600
Toluene	UG/L	26	40%	5	GA	3	6	15	7.6	4.5 J	2.5 J	4.6 J
Trans-1,2-Dichloroethene	UG/L	22	87%	5	GA	7	13	15	2.6 J	5.3	4.4 J	5 U
Trichloroethene	UG/L	760	67%	5	GA	8	10	15	5 U	2.5 J	4.8 J	5 U
Vinyl chloride	UG/L	230	100%	2	GA	15	15	15	10	31	42	23

ATTACHMENT D-3
Detected VOCs - Round 3 of Biowall Treatability Study

Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

Parameter	Units	Maximum	Frequency	Criteria	Criteria Source	No. Exceed	No. Detect	No. of Analyses	Value (Q)	Value (Q)	Value (Q)	Value (Q)
Facility									ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID									MWT-19	MWT-20	MWT-21	MWT-22
Matrix									GW	GW	GW	GW
Sample ID									ALBW20033	ALBW20032	ALBW20031	ALBW20030
Sample Depth to Top of Sample									0	0	0	0
Sample Depth to Bottom of Sample									0	0	0	0
Sample Date									12/13/2005	12/13/2005	12/13/2005	12/12/2005
QC Code									SA	SA	SA	SA
Study ID									BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS
Round									3	3	3	3
1,1-Dichloroethene	UG/L	2.9	20%	5	GA	0	3	15	2.1 J	5 U	5 U	5 U
1,2,4-Trichlorobenzene	UG/L	3.8	7%	5	GA	0	1	15	5 U	5 U	5 U	5 U
1,2-Dichloroethane	UG/L	6.8	27%	0.6	GA	4	4	15	5 U	5 U	5 U	5 U
Acetone	UG/L	4900	80%			0	12	15	180	200	73	66
Benzene	UG/L	2.9	13%	1	GA	1	2	15	5 U	5 U	5 U	5 U
Cis-1,2-Dichloroethene	UG/L	1000	100%	5	GA	15	15	15	1000	13	570	360
Methyl butyl ketone	UG/L	62	20%			0	3	15	25 U	25 U	25 U	25 U
Methyl ethyl ketone	UG/L	7600	67%			0	10	15	330	260	66	89
Toluene	UG/L	28	40%	5	GA	3	6	15	5 U	26	6.6	5 U
Trans-1,2-Dichloroethene	UG/L	22	87%	5	GA	7	13	15	17	2.2 J	22	11
Trichloroethene	UG/L	760	67%	5	GA	8	10	15	17	5 U	20	12
Vinyl chloride	UG/L	230	100%	2	GA	15	15	15	140 J	13 J	180	140

ATTACHMENT D-3
Detected VOCs - Round 3 of Biowall Treatability Study

Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

Parameter	Units	Maximum	Frequency	Criteria	Criteria Source	No. Exceed	No. Detect	No. of Analyses				
Facility									ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID									PT-12A	PT-12A	PT-22	PT-22
Matrix									GW	GW	GW	GW
Sample ID									ALBW20043	ALBW20035	ALBW20029	ALBW20042
Sample Depth to Top of Sample									0	0	0	0
Sample Depth to Bottom of Sample									0	0	0	0
Sample Date									12/14/2005	12/14/2005	12/1/2005	12/16/2005
QC Code									DU	SA	SA	SA
Study ID									BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS
Round									3	3	3	3
									Value (Q)	Value (Q)	Value (Q)	Value (Q)
1,1-Dichloroethene	UG/L	2.9	20%	5	GA	0	3	15	1 U	0.61 J	1 U	1 U
1,2,4-Trichlorobenzene	UG/L	3.8	7%	5	GA	0	1	15	1 U	1 U	1 UJ	1 U
1,2-Dichloroethane	UG/L	6.8	27%	0.6	GA	4	4	15	1 U	1 U	4.3	5.5
Acetone	UG/L	4900	80%			0	12	15	5 U	5 U	5 UJ	3.8 J
Benzene	UG/L	2.9	13%	1	GA	1	2	15	1 U	1 U	1 U	1 U
Cis-1,2-Dichloroethene	UG/L	1000	100%	5	GA	15	15	15	320	310	120	160 J
Methyl butyl ketone	UG/L	62	20%			0	3	15	5 U	5 U	5 UJ	5 U
Methyl ethyl ketone	UG/L	7600	67%			0	10	15	5 U	5 U	5 UJ	5 U
Toluene	UG/L	26	40%	5	GA	3	6	15	1 U	1 U	1 U	1 U
Trans-1,2-Dichloroethene	UG/L	22	87%	5	GA	7	13	15	4.6	5.2	2.3	3.8
Trichloroethene	UG/L	760	67%	5	GA	8	10	15	370	400	46	42
Vinyl chloride	UG/L	230	100%	2	GA	15	15	15	7.6	8.8	17	30

ATTACHMENT D-4
Detected VOCs - Round 4 of Biowall Treatability Study

Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

Facility									ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID									MWT-12R	MWT-13	MWT-14	MWT-15	MWT-16
Matrix									GW	GW	GW	GW	GW
Sample ID									ALBW20056	ALBW20055	ALBW20054	ALBW20053	ALBW20052
Sample Depth to Top of Sample									0	0	0	0	0
Sample Depth to Bottom of Sample									0	0	0	0	0
Sample Date									1/28/2006	1/28/2006	1/27/2006	1/27/2006	1/27/2006
QC Code									SA	SA	SA	SA	SA
Study ID									BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS
Round									4	4	4	4	4
Parameter	**Units**	**Maximum**	**Frequency**	**Criteria**	**Criteria Source**	**No. Exceed**	**No. Detect**	**No. of Analyses**	**Value (Q)**	**Value (Q)**	**Value (Q)**	**Value (Q)**	**Value (Q)**
1,1-Dichloroethene	UG/L	2.3	36%	5	GA	0	5	14	2.3	1 U	1 U	1 U	1 U
1,2-Dichloroethane	UG/L	8.7	36%	0.6	GA	4	5	14	0.53 J	1 U	1.9	1 U	8.7
Acetone	UG/L	1800	86%			0	12	14	5.6 J	1600	770	55 J	24 J
Carbon disulfide	UG/L	4.7	21%			0	3	14	1 UJ	1 UJ	1 J	4.7 J	1 UJ
Cis-1,2-Dichloroethene	UG/L	890	100%	5	GA	13	14	14	650	52	140	3.1	43
Methyl butyl ketone	UG/L	38	43%			0	6	14	5 UJ	38 J	17 J	5 UJ	5 UJ
Methyl ethyl ketone	UG/L	5800	79%			0	11	14	5 UJ	2000	930	33 J	15 J
Methyl isobutyl ketone	UG/L	2.6	7%			0	1	14	5 UJ	2.6 J	5 UJ	5 UJ	5 UJ
Methylene chloride	UG/L	12	7%	5	GA	1	1	14	1 U	1 U	1 U	1 U	1 U
Toluene	UG/L	28	71%	5	GA	3	10	14	1 U	2.9	1	9.8	2.8
Trans-1,2-Dichloroethene	UG/L	20	93%	5	GA	8	13	14	17	1.9	11	2.2	5.4
Trichloroethene	UG/L	540	71%	5	GA	8	10	14	540	1 U	2	1 U	2.9
Vinyl chloride	UG/L	350	100%	2	GA	14	14	14	67	55	340	5	31

ATTACHMENT D-4
Detected VOCs - Round 4 of Biowall Treatability Study

Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

Facility									ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID									MWT-17R	MWT-18	MWT-19	MWT-19	MWT-20
Matrix									GW	GW	GW	GW	GW
Sample ID									ALBW20051	ALBW20049	ALBW20048	ALBW20047	ALBW20046
Sample Depth to Top of Sample									0	0	0	0	0
Sample Depth to Bottom of Sample									0	0	0	0	0
Sample Date									1/26/2006	1/27/2006	1/27/2006	1/27/2006	1/27/2006
QC Code									SA	SA	DU	SA	SA
Study ID									BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS
Round									4	4	4	4	4
Parameter	**Units**	**Maximum**	**Frequency**	**Criteria**	**Criteria Source**	**No. Exceed**	**No. Detect**	**No. of Analyses**	**Value (Q)**	**Value (Q)**	**Value (Q)**	**Value (Q)**	**Value (Q)**
1,1-Dichloroethene	UG/L	2.3	36%	5	GA	0	5	14	1 U	20 U	1.4	1.4	1 U
1,2-Dichloroethane	UG/L	8.7	36%	0.6	GA	4	5	14	5.8	20 U	1 U	1 U	1 U
Acetone	UG/L	1800	86%			0	12	14	11	1800	170 J	170 J	410 J
Carbon disulfide	UG/L	4.7	21%			0	3	14	0.75 J	20 U	1 UJ	1 UJ	1 UJ
Cis-1,2-Dichloroethene	UG/L	890	100%	5	GA	13	14	14	97	150	890	850	8.4
Methyl butyl ketone	UG/L	38	43%			0	6	14	5 U	100 U	5.8 J	5.6 J	17 J
Methyl ethyl ketone	UG/L	5800	79%			0	11	14	6.2	5800	460 J	450 J	660
Methyl isobutyl ketone	UG/L	2.6	7%			0	1	14	5 U	100 U	5 UJ	5 UJ	5 UJ
Methylene chloride	UG/L	12	7%	5	GA	1	1	14	1 U	12 J	1 U	1 U	1 U
Toluene	UG/L	28	71%	5	GA	3	10	14	1.7	20 U	0.62 J	0.6 J	28
Trans-1,2-Dichloroethene	UG/L	20	93%	5	GA	8	13	14	4.2	20 U	20	20	1.8
Trichloroethene	UG/L	540	71%	5	GA	8	10	14	12	20 U	22	21	1 U
Vinyl chloride	UG/L	350	100%	2	GA	14	14	14	60	26	350	340	9.1

ATTACHMENT D-4
Detected VOCs - Round 4 of Biowall Treatability Study

Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

Facility									ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID									MWT-21	MWT-22	PT-12A	PT-22
Matrix									GW	GW	GW	GW
Sample ID									ALBW20045	ALBW20044	ALBW20050	ALBW20057
Sample Depth to Top of Sample									0	0	0	0
Sample Depth to Bottom of Sample									0	0	0	0
Sample Date									1/27/2006	1/26/2006	1/28/2006	1/28/2006
QC Code									SA	SA	SA	SA
Study ID									BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS
Round									4	4	4	4
Parameter	Units	Maximum	Frequency	Criteria	Criteria Source	No. Exceed	No. Detect	No. of Analyses	Value (Q)	Value (Q)	Value (Q)	Value (Q)
1,1-Dichloroethene	UG/L	2.3	36%	5	GA	0	5	14	0.74 J	0.72 J	1 U	1 U
1,2-Dichloroethane	UG/L	8.7	36%	0.6	GA	4	5	14	1 U	1 U	1 U	3.5
Acetone	UG/L	1800	86%			0	12	14	130 J	14 J	50 U	5 UJ
Carbon disulfide	UG/L	4.7	21%			0	3	14	1 UJ	1 UJ	1 UJ	1 UJ
Cis-1,2-Dichloroethene	UG/L	890	100%	5	GA	13	14	14	470	430	400	110
Methyl butyl ketone	UG/L	38	43%			0	6	14	5 UJ	5 UJ	13 J	5 UJ
Methyl ethyl ketone	UG/L	5800	79%			0	11	14	110 J	12 J	50 U	5 UJ
Methyl isobutyl ketone	UG/L	2.6	7%			0	1	14	5 UJ	5 UJ	5 UJ	5 UJ
Methylene chloride	UG/L	12	7%	5	GA	1	1	14	1 U	1 U	1 U	1 U
Toluene	UG/L	28	71%	5	GA	3	10	14	6.5	1 U	1.2	1 U
Trans-1,2-Dichloroethene	UG/L	20	93%	5	GA	8	13	14	20	13	5.6	2.6
Trichloroethene	UG/L	540	71%	5	GA	8	10	14	18	25	530	37
Vinyl chloride	UG/L	350	100%	2	GA	14	14	14	180	140	19	26

Attachment D-5
Total Organic Carbon in Soil - Biowall Treatability Study

Ash Landfill Mulch Biowall
Seneca Army Depot, Romulus, New York

Facility		ASH LANDFILL	ASH LANDFILL	ASH LANDFILL	ASH LANDFILL
Location ID		MWT-17R	MWT-17R	MWT-12R	MWT-12R
Matrix		SOIL	SOIL	SOIL	SOIL
Sample ID		ALBW10001	ALBW10002	ALBW10003	ALBW10004
Sample Depth to Top of Sample		7.4	8.2	5	5.5
Sample Depth to Bottom of Sample		7.4	8.2	5.5	5.7
Sample Date		8/12/2005	8/12/2005	8/22/2005	8/22/2005
QC Code		SA	SA	SA	SA
Study ID		BIOWALL TS	BIOWALL TS	BIOWALL TS	BIOWALL TS
Round		1	1	1	1
Parameter	**Units**	Value (Q)	Value (Q)	Value (Q)	Value (Q)
Total Organic Carbon	MG/KG	27500	15700	25800	5830

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