Environmental Restoration Program
Final Focused Feasibility Study

174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

March 2010

NGB/A7OR
Andrews AFB, Maryland

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LIST OF ACRONYMS

Acronym	Definition
μg/L	Micrograms per liter
AFB	Air Force Base
ANG	Air National Guard
ARARs	Applicable or relevant and appropriate requirements
BEX	Benzene, Ethylbenzene, and Total Xylenes
BGC	Brooklawn Golf Course
bgs	Below ground surface
BTEX	Benzene, Toluene Ethylbenzene, and Total Xylenes
CaO_2	Calcium peroxide
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Information System
cm/sec	Centimeters per second
COC	Chemicals of Concern
COPCs	Chemicals of Potential Concern
DPI	Direct Push Investigation
EPA	United States Environmental Protection Agency
ERM	Environmental Resources Management
ERP	Environmental Restoration Program
FS	Feasibility Study
ft	feet
FW	Fighter Wing
GE	General Electric
GP	Geoprobe®
IRA	Interim Remedial Action
IRM	Interim Remedial Measure
ISCO	In-situ chemical oxidation
mg/kg	Milligrams per kilograms
MNA	Monitored natural attenuation
MTBE	Methyl Tert Butyl Ether
MW	Monitoring Well
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	Non-Detect
NYSDEC	New York State Department of Environmental Conservation

LIST OF ACRONYMS

Acronym	Definition
NYSDOH	New York State Department of Health
ORM	Oxygen release material
O&M	Operation and maintenance
PCBs	Polychlorinated Biphenyls
PID	Photoionization Detector
ppm	Parts Per Million
PT	Pilot Test
RAO	Remedial Action Objective
RBC	Risk Based Concentration
RI	Remedial Investigation
RW	Recovery Well
SCGs	Standards, Criteria, or Guidelines
SCOs	Soil Clean-up Objectives
TBC	To-Be-Considered
TMV	Toxicity, mobility, or volume
TPH	Total petroleum hydrocarbons
VOC	Volatile Organic Compounds

EXECUTIVE SUMMARY

As part of the Air National Guard (ANG) Environmental Restoration Program (ERP), Environmental Resources Management (ERM) has prepared this final Feasibility Study (FS) Report for Site 15 at the 174th Fighter Wing (FW) of the New York ANG located in Syracuse, New York. The Site was listed on the New York State Inactive Hazardous Waste Disposal Site Registry in 1994 as Number 734054. As part of this program, the ANG was required to conduct remedial investigations (RIs) and complete a FS for the site.

Four remedial alternatives were evaluated in this report based on ERM's review of available data and previous discussions with the New York State Department of Environmental Conservation (NYSDEC).

- Alternative 1 — No Action. Under this alternative, no site modifications, remedial actions or monitoring would be implemented to prevent or eliminate human health and environmental risks.
- Alternative 2 — Source Removal and Monitored Natural Attenuation (MNA) of Groundwater. Alternative 2 utilizes excavation and off-site disposal of the residual impacted soil in source areas and MNA of groundwater as the primary treatment methods.
- Alternative 3 — Source Removal and Focused Enhanced Aerobic Bioremediation with MNA. Alternative 3 utilizes excavation and off-site disposal of the residual impacted soil in source areas, and aerobic bioremediation focusing active treatment on the off-site plume migration pathway with some on-site treatment to prevent further off-site migration of off-site impacted groundwater and MNA as the primary treatment methods.
- Alternative 4 — Source Removal and Expanded Enhanced Aerobic Bioremediation with MNA. In Alternative 4, the primary treatment utilizes excavation and off-site disposal of the residual impacted soil in source areas, aerobic bioremediation of the plume (both on-site and off-site) and MNA as the primary treatment methods.

Each alternative was evaluated for the remediation of chemicals of potential concern (COPCs) identified for Site soil and groundwater. A conceptual design for each alternative was developed for cost estimating purposes. A detailed analysis of the alternatives was subsequently performed in accordance with the document entitled *"Interim Final*

Guidance for Conducting Remedial Investigations and Feasibility Studies under Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLA)" (United States Environmental Protection Agency [EPA] 1988) and NYSDEC Final DER- 10 entitled "*Technical Guidance for Site Investigation and Remediation"* (NYSDEC 2002). The criteria used for this evaluation included:

- Overall protectiveness of human health and the environment;
- Compliance with applicable compliance with standards, criteria, or guidelines (SCGs);
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume (TMV);
- Short-term effectiveness;
- Implementability; and
- Reasonableness of cost.

The remedial alternatives were evaluated individually and against each other using the above criteria, and a preferred alternative was identified. With the exception of implementability and cost, Alternative 1 and Alternative 2 would not effectively comply with five of the seven criteria outlined above.

Alternatives 3 and 4 are both expected to comply with the Site's remedial action objectives (RAOs) within a reasonable timeframe; both provide protection of human health and environment, achieve the SCGs and provide long-term effectiveness. Both alternatives have limited short term impacts and both are expected to reduce TMV of site impacted media. Alternative 4 will have slightly more implementability issues than Alternative 3. Alternative 3 requires fewer injection points than Alternative 4 and is less costly.

The cost differential between the two alternatives is $260,285 favorable to Alternative 3. Therefore, given the current knowledge that the plume the plume is dissipating within the boundaries of the General Electric (GE) Property, alternative 3 appears to be the most cost-effective alternative.

Alternative 3 is the recommended remedial alternative because it satisfies the remedy-selection evaluation criteria and addresses the impacted groundwater and soil at the Site in the most cost-effective way.

SECTION 1.0

INTRODUCTION

This Final FS Report has been prepared for Site 15 at the 174th FW of the New York ANG in Syracuse, New York (the Site) presented in Figure 1-1. The Final FS was conducted as part of the ANG ERP and was completed under National Guard Bureau contract DAHA92-01-D-0005, Delivery Order 0033, between ERM and the National Guard Bureau, Departments of the Army and Air Force. The ANG ERP Branch provided technical and project management oversight for this study on behalf of the ANG. The Site was listed on the New York State Inactive Hazardous Waste Disposal Site Registry in 1994 as Number 734054. As part of this program, the ANG was required to conduct RIs and complete an FS for Site 15.

This report contains the basic elements suggested for FS reports as described in the EPA document *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988) and NYSDEC Final DER-10 entitled "*Final Technical Guidance for Site Investigation and Remediation*" (NYSDEC 2002).

The Final FS Report is based on information collected at the Site since 1990 and contained in the following documents:

- Metcalf & Eddy, 1995. *Final Technical Memorandum*. 174th Fighter Wing, New York Air National Guard, Hancock Field, Syracuse, New York. Prepared by Metcalf & Eddy for the Air National Guard Readiness Center, Andrews AFB, Maryland. February 1995.

- Lockheed, 1997. *Final Remedial Investigation Report for Petroleum, Oil, and Lubricant Facility, Site 15*. Volumes I and II. Prepared by Lockheed Martin for the Air National Guard Readiness Center, Andrews AFB, Maryland. July 1997.

- Aneptek, 1999. *Final Treatability Study/Technical Memorandum for Petroleum, Oil, and Lubricant Facility, Site 15*. 174th Fighter Wing, New York Air National Guard, Hancock Field, Syracuse, New York. Prepared by Aneptek Corporation for the Air National Guard Readiness Center, Andrews AFB, Maryland. December 1999.

- Parsons ES, 2000. *Work Plan for Data Gap Investigation, Focused Feasibility Study, and Subsequent Pre-Design and Design Tasks for Site 15 at Hancock Field, Syracuse, NY*. Prepared for National Guard Bureau and Air National Guard. December 2000.

- Parsons ES, 2001. *Work Plan for the Time Critical Removal Action at Site 15 at Hancock Field, Syracuse, NY*. Prepared for National Guard Bureau and Air National Guard. October 2001.

- Parsons, 2002. *Feasibility Study Report for Site 15* (includes Data Gap Investigation Report as Appendix A). Prepared for the Air National Guard Readiness Center, Andrews AFB, Maryland. February 2002.

- Parsons, 2003. *Remedial Action Report for the Hancock Air National Guard Site 15 and Site 1*. Prepared for the Air National Guard Readiness Center, Andrews AFB, Maryland. June 2003

- Parsons, 2004. *Remedial Action Plan for Hancock Air National Guard Site 15*. Parsons Engineering Science, Inc., Liverpool, New York, January 2004.

- ERM, 2006, *Site 15 Interim Remedial Action - Supplemental Investigation Work Plan*, 174th Fighter Wing - New York Air National Guard- Hancock Air National Guard Base – Syracuse, New York – ERM, Dewitt, New York, September 2006.

- ERM, 2007. *Site 15 Interim Remedial Action - Remedial Investigation Technical Memorandum*, 174th Fighter Wing - New York Air National Guard- Hancock Air National Guard Base – Syracuse, New York – ERM, Dewitt, New York, January 2007.

- ERM, 2008. *Site 15 Interim Remedial Action Supplemental Remedial Investigation Plume Delineation Final Technical Memorandum*, 174th Fighter Wing - New York Air National Guard- Hancock Air National Guard Base – Syracuse, New York – ERM, Dewitt, New York, June 2008.

- ERM, 2009. *Site 15 Final Construction Completion Report - Source Area Soil Removal,* 174th Fighter Wing - New York Air National Guard- Hancock Air National Guard Base – Syracuse, New York – ERM, Dewitt, New York, January 2009.

- ERM, 2009. *Site 15 Interim Remedial Action Supplemental Remedial Investigation/Focused Feasibility Study Final Technical Memorandum,* 174th

Fighter Wing - New York Air National Guard- Hancock Air National Guard Base – Syracuse, New York – ERM, Dewitt, New York, November 2009.

This FS was prepared to reflect results of additional Site 15 environmental media investigations conducted by ERM following submittal of the Parsons 2002 FS report. Based on the data obtained during these investigations, the potential remedial alternatives for Site 15 have been re-evaluated in this report.

1.1 Purpose and Organization of Report

The purpose of this Final FS Report is to describe the development and screening of remedial alternatives for contaminated media identified at the 174th FW.

The objectives of this FS are to:

- Develop, screen, and evaluate remedial alternatives to address the media of interest that present a risk to human health or the environment and/or exceed applicable SCGs; and
- Based on a detailed analysis of the alternatives, select a preferred alternative that is cost-effective and protects human health, welfare, and the environment.

This Final FS Report begins with an overview of Site 15 and a summary of previous ERP investigations, followed by the development, screening, and detailed analysis of remedial alternatives. The contents of the sections are as follows:

- Section 1.0 – Introduction;
- Section 2.0 – Remedial Action Objectives and Technologies Screening;
- Section 3.0 – Development and Screening of Remedial Alternatives;
- Section 4.0 – Detailed Analysis of Alternatives;
- Section 5.0 – Recommendations;
- Section 6.0 – References; and

- Appendix A – Bioremediation Evaluation.

1.2 Background Information

This section summarizes background information for the Site. More detailed information can be found in the ERM's *Site 15 Interim Remedial Action Supplemental Remedial Investigation Plume Delineation Final Technical Memo* dated June 2008 (ERM 2008a) and *Site 15 Interim Remedial Action Supplemental Remedial Investigation/Focused Feasibility Study Final Technical Memorandum* dated November 2009 (ERM 2009b).

1.2.1 Site Location and Topography

Site 15 is located at the 174th FW, which is based at Hancock Field, an active international airport and a former Air Force Base (AFB) located two miles north-northeast of the City of Syracuse in Onondaga County in central New York (Figure 1-1). The ANG facility is currently operating within the southern portion of the former Hancock AFB located south of the municipal airport.

The 174th FW is in the northwest portion of the United States Geologic Survey Syracuse East quadrangle. The 174th FW is on generally flat terrain gently sloping to the southeast. Surface elevations generally range from 395 to 415 feet (ft) above mean sea level.

1.2.2 Land Use

The 174th FW property and the surrounding land use is currently transportation, with the Syracuse Hancock International Airport and a mixture of recreational, industrial, commercial, and some residential properties within one-quarter mile down-gradient (south) of the site. The 174th FW is bordered by the airport to the north, the Town of Dewitt to the east and south, and the Town of Salina to the west. Lands to the west, north, and east of Site 15 are used for military and transportation purposes that have been ongoing for decades. Land directly to the south of Site 15 across Molloy Road is used as a golf course. Overall land use in the site vicinity has not changed significantly in the last 30 to 40 years and is not expected to change significantly in the foreseeable future.

1.2.3 Site Description

The 174th FW facility is currently operating within the southern portion of the former Hancock AFB located south of the municipal airport. Facilities on the base include hangers, support buildings, office buildings, and maintenance buildings (Figure 1-2).

Site 15 is approximately 2.5 acres in area and consists of brush and wooded vegetation, a large concrete pad, a formerly bermed area where a 215,000-gallon aboveground tank was located, and two drainage swales. One drainage swale borders the site along the north-northeast side, and a second borders the west side of the site. The drainage swales contain water intermittently following storm events. Water within the drainage swales does not appear to be hydraulically connected to underlying groundwater (Parsons 2004).

1.2.4 Site History

Site 15 was formerly used as a pump house for the Petroleum, Oil and Lubricants area. Site 15 has sustained spills of polychlorinated biphenyls (PCBs) and JP-4 and JP-8 military aviation fuels over the years of operation. Several site structures were removed in 2003 as part of a removal action for PCB-impacted soils, including a transformer pad, the foundation of the former pump house, six underground storage tanks, three drainage sumps and an oil-water separator (Parsons 2004).

1.2.5 Environmental Setting

The following subsections summarize the environmental setting of the 174th FW to provide context for the site characterization information and FS evaluations.

1.2.5.1 Climate

Syracuse has a four-season continental climate with marked seasonal changes. Geographical location, cyclonic systems and cold air masses affect the Syracuse weather, making winters cold with significant amounts of snow. During the summer and parts of spring and autumn, temperatures customarily rise during the daytime to fall rapidly after sunset, so the nights are relatively cool.

Temperatures (Fahrenheit) average 23 degrees in January, 46 degrees in April, 70 degrees in July and 61 degrees in September.

1.2.5.2 Sensitive Receptors

No City of Syracuse Water Department municipal wells are located within four miles of the 174th FW and no private drinking water wells within one mile of Site 15. The surrounding population obtains drinking water from municipal sources.

No critical habitats or endangered or threatened species were identified within 4 miles of the 174th FW.

1.2.5.3 Site Geology

The surficial geology at Site 15 consists of glaciofluvial sediments deposited by glacial meltwater overlying poorly sorted till deposited directly by glaciers. The glaciofluvial sediments include silty clays, sands, and gravels, with thickness ranging from 45 to 55 ft. The underlying till consists of gravel, cobbles, and boulders entrained in a silty clay matrix and ranges in thickness from 30 to 100 ft (Lockheed 1997).

Bedrock is encountered at depths ranging from 75 to 109 ft below ground surface (bgs), and is one of the Upper Silurian Vernon Formation. This formation consists of thinly bedded soft red shale with thin beds of green shale, gypsum, halite, and dolomite. Competence varies from soft and crumbly to dense and hard. The degree of competence appears to be proportional to the density of the fractures in the shale. The shale is characterized by enlarged fractures, joints, and bedding planes (Lockheed 1997).

Surficial geologic cross-sections of the Site 15 area are provided in Figure 1-3.

1.2.5.4 Local Hydrogeology

The overburden at Site 15 consists of fine-grained sediments. The subgrade soils are fairly uniform, with the upper 10 to 15 ft of the soil characterized by relatively soft, dark yellowish-brown silt and silty clay. Towards the southeast, the interval thins to approximately 5 ft. Beneath the silty clay are fine- to medium-grained sands, yellowish brown to dark brown with silt, and trace amounts of clay down to a depth of approximately 20 ft. Underlying these silty sands is a lens of stiff clayey silts (often called glacial till). Till up to 15 ft thick was encountered (Lockheed 1997).

The inferred groundwater flow direction is southeast toward Ley's Creek as shown on Figure 1-4. The water table fluctuates seasonally on the order of 2 to 3 ft, with the highest groundwater elevations occurring in winter/spring and the lowest elevations occurring in summer/fall. Hydrogeologic testing reveals that saturated hydraulic conductivity of the sand unit is generally 4.09×10^{-4} centimeters per second (cm/sec) and that contaminant transport in groundwater is occurring through the sand unit.

1.2.6 Previous Investigations

Several investigations/studies and a removal actions have taken place at Site 15 during the period from 1990 to 2009. Reports documenting these activities were listed in Section 1.0. A brief synopsis of these investigations is presented below.

1.2.6.1 Investigations and Remedial Actions Prior to 2005

A spill investigation was conducted in June 1990 resulting in the installation and sampling of four monitoring wells (MW-1, MW-2, MW-3, and MW-4). Groundwater analytical data indicated a maximum benzene concentration of 510 micrograms per liter (µg/L). PCBs were not detected in samples collected from these wells.

Six soil borings were advanced and completed as monitoring wells (MW-5 through MW-10) in November and December 1990. Groundwater samples were collected from all existing wells (MW-1 through MW-10) and analyzed for benzene, toluene, ethylbenzene, and total xylenes (BTEX) PCBs, and total petroleum hydrocarbons (TPH). Analytical data for groundwater yielded concentrations up to 700 µg/L of benzene, 520 µg/L of ethylbenzene, 1,800 µg/L of xylenes, and 2.3 milligrams per liter of TPH.

Groundwater samples were collected from nine of the 10 monitoring wells in June and July 1994. No sample was collected from monitoring well MW-5 because the well was damaged to an extent that prevented collection of a representative sample. Concentrations of TPH increased in monitoring wells MW-7 and MW-2 relative to the 1990 sampling event. However, TPH was not detected in wells MW-8, MW-9, and MW-10.

An RI was conducted in 1995 and 1996 resulting in the installation of four additional shallow monitoring wells (MW-5R, MW-11, MW-12S, MW-13) and two deeper monitoring wells (MW-6D and MW-12D). Groundwater samples were collected from all existing monitoring wells during the RI. The estimated horizontal extent of affected groundwater was delineated based on volatile organic compounds (VOCs) and semi-volatile organic compounds concentrations in groundwater. Separate-phase product resembling jet fuel was observed near the leading edge of the plume at that time. Semi-volatile organic compounds were restricted mainly to an area on the northeast side of the pump house (Lockheed 1997).

A treatability study investigation was conducted at the Site in May 1998, which resulted in the installation of four additional monitoring wells (MW-14 through MW-17) and one planned recovery well (RW-1) for the separate-phase product observed during the RI. Groundwater samples were collected for VOC analysis from the four newly installed wells. Separate-phase product was not observed in planned recovery well RW-1. Therefore, planned product recovery operations were not implemented. Benzene and/or ethylbenzene were detected in the groundwater samples collected from monitoring wells MW-14 and MW-15.

Thirty-eight temporary groundwater sampling points were installed using direct-push techniques in September and October 1999 to further delineate BTEX in Site groundwater. Three permanent wells were also installed at this time (MW-18, MW-19, and MW-20). The 38 monitoring points were screened in the field for VOCs with a photoionization detector (PID). BTEX compounds were detected in 24 of these locations. A small amount of separate-phase product resembling jet fuel was encountered in three of the temporary points and one well (MW-19).

A Data Gap Investigation was conducted in 2000 and 2001 to provide additional data regarding the extent of BTEX-affected groundwater. The Data Gap Investigation included installation of temporary groundwater sample collection points off-site at the Brooklawn Golf Course (BGC) to evaluate groundwater quality in this area. A total of 17 groundwater samples were collected and submitted for laboratory analysis. In the fall of 2001, a small amount of light non-aqueous phase liquid was observed in monitoring well MW-6. Petroleum-like sheen was also observed in monitoring wells MW-21 and MW-22 installed in the fall of 2001. BTEX concentrations in groundwater exceeded the NYSDEC ambient groundwater quality standards in two of the 21 direct-push locations at the BGC, indicating that BTEX had migrated off-site at concentrations above the NYSDEC groundwater standards.

In 2003, Parsons conducted an Interim Remedial Measure (IRM) at Site 15. As part of the IRM, Parsons removed several Site structures and soil that had PCB and/or petroleum impacts. Structures removed included a transformer pad, the foundation of the former pump house, six underground storage tanks, three drainage sumps and an oil-water separator. Approximately, 5,000 tons of soil were removed during this IRM.

1.2.6.2 ERM 2005 Investigation

ERM conducted groundwater sampling at the Site during April and September 2005. Sixteen shallow monitoring wells located on ANG property were sampled for BTEX and methyl tert butyl ether (MTBE).

The groundwater analysis from the April 2005 investigation indicated BTEX and MTBE concentrations below laboratory method reporting limits in seven of the 16 monitoring wells (MW-4, MW-5, MW-9, MW-16, MW-17, MW-18, and MW-20). The highest concentrations of BTEX were detected in wells MW-3, MW-15, MW-19, and MW-22. Benzene concentrations in these wells ranged from 29 to 200 µg/L. The highest concentrations of benzene were found at MW-3, in the source area and MW-15 and MW-22 immediately down gradient to the southeast. Ethylbenzene concentrations were highest in the source area (MW-3) and in well MW-19 adjacent to Molloy Road (the highest concentration of ethylbenzene was detected in MW-19). Xylene concentrations above the NYSDEC standard are limited to the source area and well MW-19, which had the highest concentration (650 µg/L).

The groundwater analysis from the September 2005 investigation indicated BTEX and MTBE concentrations below the laboratory method reporting limits in seven of the 16 monitoring wells (MW-4, MW-5, MW-8, MW-9, MW-16, MW-18, and MW-20). The highest concentrations of BTEX were detected in wells MW-2, MW-3, MW-15, MW-19, and MW-22. With the exception of MW-2, the same monitoring wells also had the highest concentrations of BTEX in April 2005.

Detected benzene concentrations in September 2005 ranged from 2.4 to 140 µg/L, which is slightly lower than the concentrations measured in April 2005. The highest concentration of benzene was detected in well MW-15. The highest concentration of ethylbenzene was detected in well MW-19, adjacent to Molloy Road. The ethylbenzene concentration in MW-19 in September (610 µg/L) was more than double the concentration detected in April. Xylene concentrations above the NYSDEC Class GA groundwater standard were limited to the source area and well MW-19. As in April 2005, well MW-19 had the highest reported concentration of xylene; however, the concentration increased from 650 µg/L in April to 860 µg/L in September. Toluene and MTBE were not detected at concentrations above applicable SCGs in any of the wells sampled during the plume delineation investigations in February 2008 and October 2009, suggesting that toluene and MTBE are no longer compounds of potential concern at Site 15, BGC or the RamTech property.

General groundwater flow direction was to the south/southeast in both the April and September 2005 investigations. The static groundwater levels in September 2005 were an average of 3 ft lower than in April 2005.

1.2.6.3 ERM 2006 Investigation

ERM initiated a direct push investigation (DPI) using the EPA's Triad Approach on the BGC property to delineate off-site groundwater condition and to collect continuous soil cores. The upper unit, generally from the surface to an average of approximately 12 ft bgs, consisted of a medium brown to reddish brown silty clay. The underlying unit, generally from 12 ft bgs to an average of approximately 29 ft bgs, consisted of a gray, locally medium brown to reddish brown, fine to medium grained silty sand. The third unit, generally at depths greater than 29 ft bgs, consisted of medium brown silty, clayey, and fine to coarse sand with sub-rounded gravels interpreted to be glacial till.

The extent of groundwater concentration above the NYSDEC Class GA ambient groundwater quality standards was delineated on BGC property to the eastern edge of the property along Fairway Drive based on DPI data. Data suggested that concentrations of BTEX exceeding NYSDEC Class GA groundwater quality standards have migrated further down gradient to at least one additional property beyond the BGC property. Delineation of affected groundwater beyond the BGC property was not completed during this portion of field work due to the lack of additional access agreements for the down gradient properties.

Two permanent groundwater monitoring wells (MW-101 and MW-102) were installed to replace wells that had been destroyed or covered during other activities on the 174th FW property. Five new off-site wells (MW-103 through MW-107) were installed on the BGC property. Two wells (MW-103 and MW-104) were located side-gradient of the plume based on the results of the DPI. Monitoring well MW-105 was installed within an area of BTEX-affected groundwater. Two additional monitoring wells were installed along the property boundary of BGC and Fairway Drive. Monitoring well MW-106 is located cross-gradient to the plume and MW-107 is located within the plume.

During the 2006 investigation, these new wells and existing wells were analyzed for MTBE and BTEX. The groundwater analysis from the new and existing wells indicated benzene, ethylbenzene, and/or xylene concentrations above laboratory method reporting limits in 14 of the 23 monitoring wells. Toluene and MTBE were not detected at concentrations above their Class GA groundwater standards in any of the wells or soil borings sampled during the plume delineation, suggesting that toluene and MTBE are no longer compounds of potential concern at Site 15 or the BGC property.

Benzene concentrations were detected in 8 wells ranging from 0.18J to 75 µg/L. The highest concentrations of benzene were found in the source area on Site 15 and immediately north and south of and parallel to Molloy Road on the BGC. Seven of the sixteen samples exceeded the Class GA standards.

Ethylbenzene concentrations were detected in 10 wells ranging from 0.22J to 270 µg/L. The highest concentrations of ethylbenzene were found in the source area and in the vicinity of wells MW-19 and MW-105 adjacent to Molloy Road on the north and south sides, respectively. Seven of the sixteen samples exceeded the Class GA standards.

Xylene concentrations were detected in 7 wells ranging from 0.36J to 480 µg/L. The highest concentrations of xylenes were found in the source area (Site 15) and immediately south of and parallel to Molloy Road on the BGC property. Six of the 16 samples exceeded the Class GA standards.

During the installation of MW-101 in the area of the former pump house building at Site 15, elevated PID readings were noted in the soil above the groundwater table and in the saturated soils. Four additional soil borings were installed outward from MW-101 at approximately 100-foot intervals. Elevated PID readings were encountered in three of the four soil borings. In addition to elevated PID readings, these soils possessed visual and olfactory evidence of residual petroleum. These impacted soils were located around the periphery of the previously excavated Site 15 source area.

Based upon field observation, elevated PID readings in the unsaturated zone, and a historical data review, ERM concluded that there is a significant volume of residual petroleum-affected soil in the unsaturated zone in the source area of Site 15. This presence of this affected soil above the groundwater table would likely have a negative impact on the effectiveness of the planned groundwater remediation. ERM recommended further investigation of residual petroleum in the unsaturated zone in the source area of Site 15 prior to preparation of the FS.

ERM also conducted a soil vapor survey utilizing five soil vapor sampling points to evaluate the potential for vapor intrusion in contemplated mission-critical buildings which may be constructed at Site 15. Each of the soil vapor sampling points was set at a depth of 5.5 ft bgs (consistent with a typical commercial building footer) in proposed locations of potential future buildings. It should be noted that discussions with 174th FW personnel suggest that any planned construction at or near Site 15 would likely be "slab-on–grade" (i.e., no basements). The soil vapor investigation was performed in general conformance with the New York State Department of Health (NYSDOH) document entitled *Guidance for Evaluating Soil Vapor Intrusion in the State of New York, Public Comment Final* (NYSDOH 2005). A summary of the soil vapor data is presented on Table 1-1.

1.2.6.4 ERM 2007-2008 Investigation

As discussed above, historically, concentrations in excess of the NYSDEC Class GA ambient groundwater quality standards were observed in the Site groundwater for BTEX and MTBE. However, since the beginning of 2006, toluene and MTBE were no longer observed at concentrations above the NYSDEC Class GA ambient groundwater quality standards during the quarterly sampling events. Therefore, it has been concluded that groundwater impacts at the Site are limited to only benzene, ethylbenzene, and total xylenes (BEX). Therefore, the remaining of this document will use the term BEX-impacted groundwater instead of the previously used MTBE and BTEX-impacted groundwater.

ERM initiated delineation of the BEX plume on the Ram Tech Consultants, Inc. (RamTech) property located on the east side of Fairway Drive on 28 January 2008. ERM advanced DPI soil borings along a northern to southern axis with an approximate 30-foot spacing. ERM expanded the investigation using 30- to 50-foot spacing eastward from each of the initial soil boring locations. This step-out process was repeated until it appeared that "clean" (i.e., BEX-unaffected) groundwater conditions were encountered. A total of 12 soil borings were installed in this area, and six groundwater samples and five soil samples were submitted for laboratory analyses.

Five new groundwater monitoring wells (MW-108, MW-109, MW-110, MW-111 and MW-112) were installed. One well MW-109 was installed east and one (MW-108) northeast (side-gradient) of the source area on ANG property. The three new off-site wells were installed on RamTech's property. Two of the wells (MW-110 and MW-111) were installed side-gradient to the east of the plume. The third off-site well (MW-112) was installed in the presumed center of the BEX groundwater plume just inside of RamTech's southern property line.

A groundwater sampling event was conducted for all existing monitoring wells and the five newly installed wells in February 2008. The monitoring well locations are presented on Figure 1-4.

Laboratory data associated with the February 2008 groundwater sampling event and all sampling events since 2005 are presented in Table 1-2. The groundwater analysis indicated BEX concentrations below laboratory method reporting limits in 22 of the 28 monitoring wells. Concentrations of benzene, ethylbenzene, and xylenes above the Class GA groundwater standards were present in MW-15, MW-19, RW-1, MW-101, MW-105, and MW-112.

Benzene concentrations in these six wells ranged from non-detect (ND) to 86 µg/L. The highest concentration of benzene was found in the area immediately south of Molloy Road on the BGC property.

Ethylbenzene concentrations in these six wells ranged from ND to 410 µg/L. Ethylbenzene concentrations were highest in the vicinity of wells MW-105 and MW-112 south of Molloy Road on the BGC property and along RamTech's southern property line.

Xylene concentrations in these six wells ranged from ND to 740 µg/L. Xylene concentrations were highest in the vicinity of wells MW-105 and MW-112 just south of Molloy Road on the BGC property and along RamTech's southern property line.

Toluene and MTBE were not detected at concentrations above the Class GA groundwater standards in any of the wells sampled during the plume delineation, suggesting that toluene and MTBE are no longer compounds of potential concern at Site 15, BGC or the RamTech property.

Based on the additional investigation previously described in the 2008 Technical Memorandum, the extent of BEX-affected groundwater was delineated on the 174th FW property, the BGC property and the RamTech property. However, available data indicate that BEX-affected groundwater also extends beyond the RamTech property towards the south and/or southeast beneath the GE property.

In addition to groundwater sampling, a total of 44 soil borings were installed to delineate the extent of the residual contamination in the Site 15 source area located above saturated soil. PID results from soil screening in the unsaturated zone ranged from ND to 1,754 parts per million (ppm) in these soil borings. Based on field observations, 10 soil samples were selected for laboratory analyses for VOCs. More detailed discussions are presented in the *Site 15 Interim Remedial Action Supplemental Remedial Investigation Plume Delineation Final Technical Memo*, dated June 2008 (ERM 2008a).

1.2.6.5 ERM 2009 Investigation

Data from ERM's 2007 investigation on RamTech property suggested that BEX concentrations exceeding groundwater standards had migrated down-gradient onto the GE property and potentially onto the National Grid and PCI Paper Conversions Inc. properties (see Figure 1-5). ERM proposed a Supplemental RI via DPI to delineate the leading edge of the plume, including installation of borings and wells on the GE, National Grid and PCI properties. ANG requested access agreements from PCI Paper Conversions Inc., National Grid, BGC, Midcourt Builders Corporation, RamTech, and GE. Access agreements were received from all parties except GE. Based on discussions with ANG personnel and the access provided by the other property owners, it was decided that the off-site investigation should proceed on properties other than the GE site to allow delineation of the groundwater plume.

ERM conducted the 2009 RI work in phases to keep the groundwater plume delineation investigation proceeding while awaiting access to GE Property. The four phases of the 2009 Remedial Investigation are outlined below, (with the exception of Phase 2 and 4 all work was conducted off-site):

1) The first phase of work conducted in late February and early March 2009 included a DPI on the National Grid property adjacent to the southern and eastern property lines of the GE site. The purpose of this investigation was to determine whether BEX-affected groundwater extended to the south and east of the GE property.

2) The second phase of work conducted in April 2009 included a baseline groundwater sampling effort in selected wells (MW-19 (on-site), MW-105, MW-106, MW-107, MW-111, and MW-112 (off-site) followed by the in-situ chemical oxidation (ISCO) pilot test (PT) via injection of calcium peroxide (CaO_2) in 20 locations. This work is further discussed in Sections 1.2.10.2 and 3.1.2.2.

3) The third phase of work was conducted in late July 2009 along the western edge of the GE property on the unpaved portion of Fairway Drive and along the southeast portions of BGC. This work included a DPI to determine if BEX-affected groundwater extended to the west of this GE property. This third phase also included: the installation of two additional permanent sentinel monitoring wells, one south (MW-113) of the GE property line and one east (MW-114) of the GE property line. After development of the two new sentinel well, an additional round of groundwater sampling of the previously referenced (second phase) selected wells plus the two new sentinel wells was performed in early August 2009.

4) The fourth phase of work conducted in early October 2009 consisted of a soil vapor survey adjacent to the RamTech Facility and along the northern property line of GE and a groundwater sampling event that incorporated all existing (on-site and off-site) wells and the two newly-installed sentinel wells.

Additional, more detailed discussion regarding the 2009 investigative work is presented in the *Site 15 Interim Remedial Action Supplemental Remedial Investigation/Focused Feasibility Study Final Technical Memorandum* dated November 2009 (ERM 2009b). Following is a summary of this work.

Investigation South and East of GE Property (Phase 1)

ERM utilized EPA's Triad Approach to delineate the extent of BEX-impacted groundwater to the south of the site in the vicinity of the GE property. Boreholes were installed to the south and the east of the GE property at locations Geoprobe® (GP)-123 through GP-141 as shown on referenced on Figure 1-5. ERM set up a boring grid at approximate 30-foot spacing along the southern and eastern property lines of GE. A total of 19 borings were installed to assess whether BEX-affected groundwater extended beyond the southern and eastern properties lines of GE.

The DPI was conducted using a Geoprobe®. Macrocore samplers were used to collect continuous soil cores during drilling operations. A calibrated PID was used to conduct headspace VOC screening of the soil cores. As per previous investigations, "Clean" soils were determined based upon field screening of soil with a PID reading less than 20 ppm. This investigation did not reveal any samples greater than 0.3 ppm, thus no soil samples were retained or submitted for laboratory analysis. Each boring was advanced to depths of 19 to 25 ft bgs to the geologic unit where BEX-affected groundwater has been encountered up gradient during previous investigations. The average depth of saturated soil in this area during the investigation was 2 to 5-ft bgs.

All 19 of the borings were extended to the groundwater table to define the extent of groundwater contamination and to locate "clean" conditions at the southern and eastern GE property lines and groundwater samples were collected using an SP-16 sampler. BEX was not detected above the laboratory's reporting limit for any of the compounds analyzed in any of the 19 boring locations.

<u>Investigation Along Fairway Drive and Monitoring Well Installations (Phase 3)</u>

ERM installed five boreholes at locations GP-142 through GP-146 as shown on Figure 1-5. A groundwater sample was collected and analyzed for BEX from each boring location as outlined above.

The installation of the five additional borings noted above was conducted west of the GE Property to delineate the extent of BEX-affected groundwater. The five borings were installed to assess whether the BEX-affected groundwater plume extended beyond the western property lines of GE. Each boring was advanced to depths between 19- to 25-ft bgs. The average depth of saturated soil in this area during the investigation was 3 to 4-ft bgs.

PID results from soil screening in the unsaturated zone were ND. All five of the borings were extended to the groundwater table to define the extent of groundwater contamination and to locate "clean" conditions along the western GE property lines. BEX was not detected above the laboratory's reporting limit of each compound in all five of these referenced groundwater samples.

Two new groundwater monitoring wells (MW-113 and MW-114) were installed during this Supplemental RI based on the results of the borehole groundwater samples. The two new off-site wells were installed just south of the south central portion of the GE property line (MW-113) and just east of the east central portion of the GE property line MW-114).

Based on previous SP-16 sampling results obtained during the February 2009 phase of this Supplemental RI, these wells should be considered sentinel wells. The two new monitoring well locations are presented on Figure 1-5.

Groundwater Sampling (Phase 4)

A complete groundwater sampling event was conducted by ERM during the week of 5 October 2009. All existing monitoring on-site and off-site wells and the two newly installed wells (total of 30 wells) were sampled in conformance with EPA low-flow (minimal drawdown) well purging and sample collection techniques (EPA 1996). All monitoring well locations are presented on Figure 1-4.

Depth to groundwater was measured to the nearest 0.01-foot using an electronic water level indicator or an interface probe. The water level indicator and the interface probe were decontaminated between wells using decontamination procedure outlined in the Work Plan. A static groundwater elevation contour map for October 2009 is also presented on Figure 1-4.

Laboratory data associated with groundwater sampling are presented in Table 1-2. The groundwater analysis indicated BEX concentrations below laboratory method reporting limits in 20 of the 30 monitoring wells. Concentrations of BEX above the NYSDEC groundwater standards were present in MW-2, MW-11, MW-14, MW-15, MW-19, MW-22, MW-101, MW-103, MW-105, and MW-112. The extent of the BTEX plume as encountered between 1995 and October 2009 is shown on Figure 1-6.

Benzene concentrations in these ten wells ranged from ND to 49 µg/L. Figure 1-7 shows the lateral extent of benzene in groundwater in October 2009 using all 30 MW sampling locations and relative to the NYSDEC ambient groundwater quality standard of 1 µg/L (NYSDEC 1998). The highest concentration of benzene was found in the area immediately north of Molloy Road on the ANG property.

Figure 1-8 illustrates the distribution of dissolved ethylbenzene in October 2009 using all the 30 MW locations and relative to the NYSDEC ambient groundwater quality standard of 5 µg/L. Ethylbenzene concentrations in these ten wells ranged from ND to 380 µg/L.

Ethylbenzene concentrations were highest in the vicinity of well MW-19 north of Molloy Road on the ANG property.

Figure 1-9 shows the distribution of dissolved xylenes in October 2009 using all 30 MW sampling locations and relative to the NYSDEC ambient groundwater quality standard of 5 µg/L. Xylene concentrations in these ten wells ranged from ND to 420 µg/L. Xylene concentrations were highest in the vicinity of well MW-19 north of Molloy Road on the ANG property.

Based on the additional investigation described in this section, the extent of BEX-affected groundwater has been delineated on the Hancock ANGB property, BGC property, and on the RamTech property with the plume dissipating within the boundaries of the GE Property.

Soil Vapor Survey (Phase 4)

ERM performed a soil vapor survey on 5 and 6 October 2009 at the three locations as shown on Figure 1-5. A soil vapor sample was collected adjacent to the west and south exterior walls of the RamTech Building and one location along RamTech's southern property line with GE. Soil vapor samples were collected from a depth consistent with a typical commercial building footer (approximately 3 to 4 ft bgs) or a minimum of 1 foot above groundwater. In addition, one ambient outdoor air sample was collected upwind during soil vapor sampling activities. The soil gas samples were used to evaluate the potential for vapor intrusion risks in the buildings. The soil vapor samples were installed and collected as per Section 2.7.1 of the *Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York (*NYSDOH 2005).

New York State does not currently have any standards for BEX in subsurface vapors. Additionally, there are no current databases available with background levels of BEX in soil vapor.

The results of the soil vapor study conducted on RamTech's property are presented in Table 1-3 and summarized in the table below. The results of the soil vapor study were compared to a 90th percentile results for the 2003 NYSDOH study documented in *Study of Volatile Organic Chemicals in Air of Fuel Oil Heated Homes* (NYSDOH 2003)[1]. A detailed evaluation of these results is presented in Section 1.2.9.2.

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[1] Between 1997 and 2003, the New York State Department of Health (NYSDOH) conducted a study of the occurrence of volatile organic chemicals (VOCs) in the indoor air of homes that heat with fuel oil. The purpose of the study was to characterize the indoor environment of fuel oil heated homes as a means of evaluating post clean-up

Identification	Benzene	Ethylbenzene	m,p - Xylene	o- Xylene
SV-06	2.14	0.97	0.90	0.57
SV-07	3.43	**3.12**	**4.19**	**2.92**
SV-08	**12.1**	1.08	1.14	0.61
Ambient Air	<0.79	<0.39	<0.39	<0.39
Indoor 90th Percentile(1)	15	7.4	12	7.6
Outdoor 90th Percentile (1)	4.3	1.1	1.4	1.7

Concentrations in µg/cubic meter

(1) The 90th percentile value represents the value below which 90% of the results fall. The bolded concentrations exceed the background outdoor air 90th percentile value as noted in the NYSDOH study.

1.2.7 Nature and Extent of Contamination

1.2.7.1 Groundwater

As discussed above, BEX compounds were detected in groundwater above the NYSDEC Class GA groundwater standards. The extent of BEX in groundwater determined from the October 2009 data is shown in Figures 1-7, 1-8, and 1-9. Based on the additional investigation described in Section 1.2.6.5, the extent of BEX-affected groundwater has been delineated on the Hancock ANGB property, BGC property, and on the RamTech property with the plume dissipating within the boundaries of the GE Property.

1.2.7.2 Soil

During ERM's 2007-2008 RI described in Section 1.2.6.4, additional residual impacted soil was discovered in the vicinity of the Site 15 source area. Three areas were identified as areas of residual impacted soil in the unsaturated zone. Those areas were defined as Areas A, B, and C as shown in Figure 1-10. A soil excavation Interim Remedial Action (IRA) to remove the BEX-affected soil was completed as described in Section 1.2.10.1.

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conditions in residences affected by petroleum spills. The study included basement, living space and outdoor samples from 104 homes, tested during both heating and non-heating seasons. Most of the more than 600 samples collected in the study were analyzed for 69 individual VOCs.
(http://www.health.state.ny.us/environmental/indoors/air/fuel_oil.htm)

1.2.8 Contaminant Fate and Transport

In general, the fate and transport of BEX in groundwater is controlled by the hydraulic conductivity and hydraulic gradient in the saturated zone, the compound's affinity for organic carbon in soil, rates of volatilization, biodegradation, and the solubility-based diffusive dilution of the compound in the saturated zone.

Investigation results indicate that the primary transport mechanism for dissolved BEX in groundwater at Site 15 is advection (i.e., bulk groundwater flow). Water level data indicate that groundwater flow at the site is towards the southeast. Advective transport of BEX compounds in groundwater is impeded ("retarded") by the compound's adsorption to organic material in soil, its tendency to volatilize, and by natural degradation processes.

Benzene, ethylbenzene, and xylenes naturally attenuate in the environment through multiple mechanisms including advection, dispersion, adsorption, volatilization and degradation. The physical mechanisms of advection, dispersion and adsorption result in the attenuation of concentration in groundwater with distance, but do not remove mass. Volatilization removes mass from the soil and groundwater into the atmosphere where photodegradation can occur. The major mass removal processes for BEX and other hydrocarbons are aerobic and anaerobic biodegradation. The major biological degradation processes occurring within the dissolved plume are anaerobic processes – sulfate reduction and iron reduction. Aerobic degradation is also occurring, as evidenced by the depletion of oxygen within the plume; however, this process is limited by the availability of oxygen. A detailed evaluation of biodegradation based on ERM investigations at Site 15 is provided in Appendix A.

Near MW-101, MW-22, and MW-3 in the vicinity of the source area at Site 15, the rates of these processes have been sufficient to attenuate the concentrations of the dissolved VOCs. However, beneath the shallow silty unit, with a relatively low (3.64×10^{-7} cm/sec), is a more permeable fine to medium silty sand unit with a hydraulic conductivity of 4×10^{-4} cm/sec. Geologic cross-sections developed based on the DPI investigations in the source area and off-site on the BGC and RamTech properties are suggestive of a sand channel in this more permeable unit that may be acting as a preferential flow path for dissolved-phase VOCs, as presented in Figure 1-3. Migration of VOCs by advective flow in this unit has resulted in the off-site plume. Although biodegradation through aerobic and anaerobic processes is occurring in the off-site plume, the rate of attenuation appears to be less than the rate of down gradient flux.

Based on the investigation activities conducted by ERM, it became apparent that additional source material was located in the vicinity of the areas previously excavated by Parsons. This impacted soil provided a source for leaching to groundwater and was removed during the IRA discussed in Section 1.2.10.1. Removal of the additional source material will reduce the rate of down gradient flux.

1.2.9 Baseline Exposure Risk Assessment

This Section discusses the exposure assessment conducted for the Site soil and groundwater. Please note this assessment considers soil conditions prior to any soil excavation and PT activities already completed as IRAs and discussed in Section 1.2.10.

1.2.9.1 Soil

The COPCs in soil were determined by comparing the detected concentrations in soil to the NYSDEC Part 375 – 6.8 (a) Soil Clean-up Objectives (SCOs) for unrestricted use. Comparison of the Site soil concentrations to the SCOs indicates that three (3) compounds (benzene, ethylbenzene, and xylenes) in Site soil exceeded Part 375(a) SCOs for unrestricted use. The unrestricted use SCO represents the lowest of the three values for protection of groundwater, ecological resources and public health that have been established by NYSDEC.

Although the intended use of the property will be commercial, the unrestricted uses of SCOs were used to screen COPCs. NYSDEC Part 375 – 6.8 (b) SCOs presents standards for the protection of human health given the intended use of the Site and for the protection of groundwater. Based on this evaluation, benzene, ethylbenzene, and xylenes were identified as COPCs for Site soil.

To further evaluate which chemicals may potentially pose a human health exposure via each of the above pathways at the Site, the maximum detected concentration of each of the chemicals of concern (COCs) was compared to these EPA Region III risk based concentrations (RBCs) as well as the SCOs.

Direct Contact with Soil

The Site is currently an active commercial and industrial Site that is fully fenced to restrict access to trespassers, and none of the COCs identified for soil exceeded protection of public health SCOs for restricted commercial use, which accounts for several direct contact scenarios for both visitors and Site workers (the potential receptors of concern). In addition, to evaluate potential risks to Site workers and visitors, maximum detected concentrations of the COPCs in Site soil were also compared to criteria appropriate for commercial/industrial exposures. Region III of EPA has established acceptable levels of chemicals in soil based on direct contact with soil by commercial/industrial workers in occupational settings RBCs (EPA 2007). None of the COCs identified for soil exceeded the direct contact RBCs for commercial/industrial use.

Therefore, under current conditions, direct contact with soil COPCs (benzene, ethylbenzene, and xylenes) present at a limited number of subsurface locations does not represent a significant human exposure pathway for Site workers and visitors as maximum detected concentrations for these compounds did not exceed the applicable direct contact criteria for current use.

Volatilization of Chemicals in Soil to Indoor and Outdoor Air

All three COPCs in soil are VOCs. Inhalation of VOCs by Site workers and visitors may represent a complete exposure pathway if volatilization of a significant mass of VOCs from soil to ambient air is occurring. None of the COCs identified for soil exceeded Part 375 (b) SCOs for the protection of public health in restricted commercial use, which also accounts for potential inhalation exposures for both visitors and Site workers.

In addition, ERM conducted a soil vapor survey utilizing five soil vapor sampling points to evaluate the potential for vapor intrusion in contemplated mission-critical buildings which may be constructed at Site 15. It should be noted that discussions with 174th FW personnel suggest that any planned construction at or near Site 15 would likely be "slab-on–grade" (i.e., no basements). A summary of the soil vapor data is presented on Table 1-1 and detections were observed in the identified source areas further discussed in the June 2008 Technical Memorandum (ERM 2008a).

New York State does not have indoor air or soil vapor quality standards or guidance documents for BTEX. According to the NYSDOH soil vapor data typically can not be relied alone to rule out the potential for vapor intrusion into a buildings. In the absence of this standards or guidance, the

NYSDOH and NYSDEC often compare soil vapor concentrations detected at a Site to the results of a background study conducted by the NYSDOH at home heated with fuel oil (NYSDOH 2003).

VOCs concentrations exceeding the 90th percentile of the background outdoor air samples in the NYSDOH study are considered to be a concern. Such concentrations suggest there is a source proximal to the study area which poses a potential risk for soil vapor to migration and intrude into a building. Soil vapor sampling is considered a screening method to determine if additional indoor air sampling will be required within an occupied building in or near a study area, to evaluate the potential exposure risk to the occupants. Therefore, although this exposure pathway is complete, there does not appear to be an unacceptable risk under current use (vacant field).

Leaching of Chemicals from Soil to Groundwater

Three VOCs (benzene, ethylbenzene, and xylene) were detected at concentrations exceeding Part 375 (b) SCOs for the protection of groundwater criteria, which suggests that leaching from soil to groundwater may be occurring in the source area. The VOCs detected in soil in excess of the groundwater protection criterion are also identified as COPCs in groundwater. This is a complete pathway. In conclusion, these three (3) VOCs in soil may potentially affect groundwater quality at the Site and are therefore further evaluated in Section 1.2.9.2.

1.2.9.2 Groundwater

Based on groundwater data from 2006 to present, there are three (3) VOCs that are considered COPCs in Site groundwater (benzene, ethylbenzene, and xylenes). These VOCs were detected at concentrations that are greater than NYSDEC's Class GA ambient groundwater quality standards. Impacted groundwater has migrated off-site. However, groundwater is not currently used for any purpose at the Site or in the vicinity of the Site.

Ingestion of Groundwater and Direct Contact with Groundwater

Groundwater at the Site and in the vicinity of the Site is not currently used for drinking water or any other potable purposes based on the results of the well search. Therefore, ingestion of groundwater and direct contact with groundwater do not represent complete exposure pathways for Site workers or visitors in the short term.

Inhalation of Chemicals from Groundwater

The presence of three VOCs in on-site groundwater may result in a complete exposure pathway if volatilization of a significant mass, escape from the subsurface and subsequent inhalation by Site workers and visitors occurs.

ERM performed a soil vapor survey on 5 and 6 October 2009 at three locations adjacent to the RamTech Facility on Fairway Drive. A soil vapor sample was collected adjacent to the west and south exterior walls of the RamTech Building and, one location along RamTech's southern property line (northern boundary of GE) proximal to the building located on the GE property. Soil vapor samples were collected from a depth consistent with a typical commercial building footer (approximately 3 to 4 ft bgs) or a minimum of 1 foot above groundwater. In addition, an ambient outdoor air sample was collected upwind during soil vapor sampling activities. The samples were used to evaluate the potential for vapor intrusion risks in the buildings.

The soil vapor samples were installed and collected as per Section 2.7.1 of the *Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York (*NYSDOH 2005). Stainless steel rods equipped with a detachable stainless steel drive point were driven to the desired sampling depth. Soil vapor samples were collected in axial sorbent tubes using positive displacement pumping. Sorbent methodology uses EPA Method TO-17 to analyze soil vapor samples for the presence of VOCs and for this application the analytes were limited to BEX. Method TO-17 is an approved analytical method in the *Guidance for Evaluating Soil Vapor Intrusion in the State of New York* (NYSDOH 2005).

New York State does not currently have any standards for concentrations of BEX in subsurface vapors. Additionally, there are no current databases available with background levels of BEX in soil vapor. In the absence of this information, soil vapor sampling results are reviewed "as a whole," in conjunction with the results of other environmental sampling and the site. To put some perspective on the data, the NYDOH and NYSDEC often compare the soil vapor results to the NYSDOH's background database that was used to evaluate outdoor air data (NYSDOH 2005).

The results of the soil vapor study conducted on RamTech's property are summarized in the table below. The study was conducted to characterize the nature and potential extent of subsurface vapor contamination on the property. The results of the soil vapor study are compared to a statistical evaluation of background concentrations of BEX in outdoor air which are summarized in the *Study of Volatile Organic Chemicals in Air of Fuel Oil Heated Homes* (NYSDOH 2003).

Identification	Benzene	Ethylbenzene	m,p – Xylene	o- Xylene
SV-06	2.14	0.97	0.90	0.57
SV-07	3.43	**3.12**	**4.19**	**2.92**
SV-08	**12.1**	1.08	1.14	0.61
Ambient	<0.79	<0.39	<0.39	<0.39
Indoor 90th	15	7.4	12	7.6
Outdoor 90th	4.3	1.1	1.4	1.7

(Concentrations in µg/cubic meter)

The bolded concentrations in the tabular summary exceed the background outdoor air concentrations of 90% of samples collected in the NYSDOH study. According the NYSDOH, soil vapor data alone typically can not be relied alone to rule out the potential for vapor intrusion in a buildings. Based on the evaluation of soil vapor and groundwater data collected in the vicinity of the RamTech building, ERM has recommended that an indoor air evaluation should be performed within the RamTech Facility

Direct Contact with Groundwater

Due to the shallow depth to groundwater and the chemical concentrations observed in Site groundwater, direct contact with impacted groundwater may pose a risk to construction workers. No groundwater criteria based on direct contact exposures were available; therefore, this pathway was not evaluated further.

1.2.10 Interim Remedial Actions

1.2.10.1 ERP Site 15 - Source Area Soil Removal

The purpose of this IRA was to remove the majority of the "grossly contaminated" petroleum-affected soil in the source area at Site 15 overlying groundwater as delineated in ERM's 2007-2008 Investigation discussed in Section 1.2.6.4. The proposed excavation limits, which were documented in *Work Plan - Final Interim Remedial Action – Source Area Removal Work Plan* (ERM 2008b), are presented in Figure 1-10 (Areas A, B, and C located within ERP Site 15). Removal of this petroleum affected material was anticipated to have a significant positive effect on the effectiveness of planned future groundwater remediation and to reduce the potential threats to human health and the environment.

Petroleum-affected soil was excavated in substantial conformance with the proposed Work Plan, *A Final Interim Remedial Action – Source Area Removal Work Plan* (ERM 2008b) which was submitted to the NYSDEC in July 2008 and verbally approved by the NYSDEC. Excavation work was completed in August 2008; the actual extent of excavation and location of confirmation samples is reflected in Figures 1-11 and 1-12 respectively. Full documentation of the soil excavation effort was contained in the *Site 15 Final Construction Completion Report - Source Area Soil Removal* dated January 2009 (ERM 2009a), which was also verbally approved by NYSDEC.

A detailed discussion of this IRA is presented in Section 3.1.2.1.

1.2.10.2 In-Situ Chemical Oxidation Pilot Test

ERM prepared and submitted the *Site 15 Supplemental RI/PT Work Plan* in October 2008 (ERM 2008c). ERM conducted an enhanced natural attenuation ISCO PT, southwest of the RamTech facility, west of along Fairway Drive, north and south Molloy Road to evaluate the effectiveness of enhanced natural attenuation within the BEX-plume.

Approximately 20 injection points were installed over a period of 4 days during the week of 11 May 2009 using direct-push technology in the locations depicted on Figure 1-13. A detailed discussion of this IRA is presented in Section 3.1.2.2.

SECTION 2.0

REMEDIAL ACTION OBJECTIVES AND TECHNOLOGIES SCREENING

This section discusses RAOs and general response actions and identifies potentially applicable technologies established for the Site media of interest (i.e., soil and groundwater). The remediation technologies are then screened using criteria of effectiveness, implementability, and cost. Technologies that are retained at the end of this section are carried over to Section 3.0 for the development and screening of remedial alternatives.

Remedial goals are derived from the statute (i.e., Title 6, New York Code of Rules and Regulations [6NYCRR] Part 375) and NYSDEC guidance. Guidance on developing RAOs is provided in NYSDEC TAGM Number 4030 (NYSDEC 1990) and examples of RAOs are also set forth in DER-10 (NYSDEC 2002). The RAOs are media-specific targets that are aimed at protecting public health and the environment. In the case of protection of human health, RAOs usually reflect the concentration of a COPC and the potential exposure route. Protection may be achieved by reducing potential exposure (e.g., use restrictions, limiting access) as well as by reducing concentrations. RAOs, which are established for protection of environmental receptors, are usually intended to preserve or restore a resource. As such, environmental RAOs are set for a media of interest and a target concentration level.

Media that are candidates for remedial evaluation are identified based on the nature and extent of contamination and applicable or relevant and appropriate SCGs. As discussed in Section 2.2, potential Site media of interest are soil and groundwater as discussed in Section 1.2.7. As identified in 6 NYCRR 375-1.10(c)(1)(ii), SCGs are provided in NYSDEC guidance. The most recent NYSDEC guidance containing SCGs is final DER-10 (NYSDEC 2002).

In addition to SCGs, certain site-specific factors are considered when developing the RAOs for Site media of interest. These site-specific factors relate to the affected media, types of constituents and potential routes of exposure. The factors that were considered in developing RAOs are discussed in the following subsections according to the media evaluated.

2.1 Identification of Standards, Criteria, or Guidelines

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) establishes applicable or relevant and appropriate requirements (ARARs) and defines To-Be-Considered (TBC) information as other advisories, criteria or guidance. Additionally, the NCP acknowledges that proposed standards issued by federal or state agencies, while not meeting the definition of an ARAR, should also be considered in remedial decisions (NCP at 40 CFR 300.400(g)(3)). The preamble to the NCP states that TBCs are to be used on an "as appropriate" basis.

SCGs incorporate both the CERCLA concepts of ARARs and TBCs. They include promulgated requirements and non-promulgated guidance, which govern activities that may affect the environment. The standards and criteria are those cleanup standards, standards of control and other substantive requirements, criteria or limitations that are officially promulgated under federal or state law. Though guidance does not represent a legal requirement, it should be considered based on professional judgment when applicable to site conditions (NYSDEC 2002).

Table 2-1 presents potential SCGs, which may govern remedial actions at the Site. This table lists: the citation; a description of the SCG; SCG type (i.e., chemical, action or location specific); and, reason the SCG is listed (e.g., remedy selection and/or remedial action) and how it applies to the remedy evaluation. Also, there is a TBC category identifying proposed SCGs that are also considered in the remedial alternative evaluation.

Certain SCGs are considered in the development of the Site media of interest RAOs. These SCGs are discussed in remedial requirements for the media of interest in the following sections. The relevance of the SCGs and TBCs to the remedial alternatives is discussed with the evaluation of each alternative in Section 4.0 (i.e., in the evaluation of the ability of each remedial action alternative to comply with the SCGs).

2.2 Media of Interest

Two environmental media were identified during the RIs conducted by ERM between 2005 and 2009 and are evaluated below as potential media of interest requiring RAOs: soil and groundwater.

Table 2-2 presents COPCs identified during previous RIs and COPCs considered for this Final FS. The COPCs are compounds showing exceedances of SCGs. Historically, there had been exceedances of BTEX and MTBE in the Site's groundwater; however, since the beginning of 2006, toluene and MTBE were no longer observed above NYSDEC's Class GA ambient groundwater quality standards in quarterly sampling. Therefore, groundwater at the Site is currently only impacted above SCGs by BEX compounds.

As previously discussed, residual soil contamination was observed in the vicinity of the former area excavated by Parsons (i.e., the Site 15 source area). The soil concentrations in this area have been compared to NYSDEC Part 375-6.8(b) SCOs for the protection of groundwater to determine soil remedial needs.

The primary chemical-specific ARAR for groundwater at the Site are the NYSDEC Class GA Ambient Water Quality Standards. These standards are contained in the *NYSDEC Division of Water Technical and Operational Guidance Series Memorandum Number 1.1.1* (TOGS 1.1.1; NYSDEC 1998).

The NYSDEC criteria for the compounds present in groundwater are listed below. The values shown for BEX are ambient water quality standards.

- Benzene: 1 µg/L
- Ethylbenzene: 5 µg/L
- Xylene: 5 µg/L

2.2.1 Soil

Site 15 soil analytical data prior to the 2008 Source Soil Removal IRA described in Section 1.2.7.1 are summarized in Table 2-3 and sample locations are depicted in Figure 1-10. One of the 10 soil samples submitted for laboratory analysis of BTEX and MTBE had detected concentrations that exceeded NYSDEC Part 375-6.8(b) SCOs for the protection of groundwater. In soil boring SB-10, benzene and ethylbenzene were detected at 0.670 milligrams per kilograms (mg/kg) and 25 mg/kg, respectively. These concentrations exceeded the NYSDEC Part 375-6.8(b) SCOs of 0.060 mg/kg and 1.0 mg/kg, respectively. Total xylenes were detected in the referenced boring at a concentration of 90 mg/kg. These concentrations exceed the NYSDEC Part 375-6.8 (b) Recommended SCOs for the protection of groundwater of 1.6 mg/kg.

Soil water agitation testing was also conducted in the field using a calibrated PID for seven soil samples exhibiting a range of PID readings to evaluate the potential for grossly impacted soil. Residual petroleum (sheen) was observed on water following the agitation testing in soil samples exhibiting PID readings of 628 ppm and greater (see Table below). This is considered to be an indication of grossly contaminated soil per NYSDEC *Final Technical Guidance for Site Investigation and Remediation* (NYSDEC 2002). The NYSDEC requires remediation of "grossly contaminated soil" during source removal actions. Grossly contaminated soil contains "visibly identifiable or otherwise readily detectable free or residual product" as defined in the NYSDEC Division of Environmental Remediation guidance document entitled *Final Technical Guidance for Site Investigation and Remediation* (NYSDEC 2002).

BORING ID	PID RESULTS (PPM)	SHEEN PRESENT
SB-32-8	0	NO
SB-16-8	60	NO
SB-2-6.5	143	NO
SB-1-2.5	225	NO
SB-17-6	628	YES
SB-7-5	1,498	YES
SB-28-14.5	2,167	YES

2.2.2 Groundwater

Table 1-2 presents a summary of VOCs detected in Site groundwater during four sampling events between April 2005 and October 2009 as compared to Class GA groundwater standards for BTEX compounds and TAGM 4046 (NYSDEC 1994) for MTBE. As shown in this table, a total of three VOCs have been detected at concentrations in excess of their SCGs as listed below:

- Benzene;
- Ethylbenzene; and
- Xylene.

Field and laboratory analytical data relevant to the evaluation of natural attenuation processes in Site groundwater was collected during ERM's RIs and groundwater sampling events that were initiated in April 2005. These data are also presented in Table 1-2. The geochemical data indicate that the major mass removal processes for BEX within the dissolved plume at the site are anaerobic processes – sulfate reduction and iron reduction. Aerobic degradation is also occurring, as evidenced by the depletion of oxygen within the plume; however, this process is limited by the availability of oxygen. A detailed evaluation of biodegradation based on ERM investigations at Site 15 is provided in Appendix A.

2.2.3 Extent of Impacted Media

The extent of the impacted media and the methodology employed to determine such extent is described below.

2.2.3.1 Soil

The extent of affected soil was determined based on exceedances of any of the following standards:

- NYSDEC Part 375-6.8(b) SCOs for the protection of groundwater;
- Agitation test/PID readings >628 ppm in the RI soil borings (Note: This corresponds to visible residual petroleum (sheen) in the Site agitation tests – see above); and
- Soil locations where detectable concentrations of VOC COPCs were observed in soil vapor (see Section 1.2.9.1).

Thus, by evaluating the results of available soil laboratory data from Site 15, results of the sheen testing and soil vapor detections, three areas were identified as areas of affected soil in the unsaturated zone. Those areas were defined as Areas A, B, and C as shown in Figure 1-10 and listed in the table below. Note that the soil gas detection in SV-101 for ethylbenzene was not considered as an affected area as no other exceedances were noted in the vicinity of SV-101. Furthermore, as discussed in Section 1.2.9.1, based on the NYSDOH information and using the worst case sample result (SV-101), there was there does not appear to be an unacceptable risk under current use (vacant field). Based on the dimensions and impacted depths of those areas, the estimated volume of affected soil requiring remediation or removal was estimated to be approximately 2,000 cubic yards or 3,000 tons.

Area ID	Size	Zone of Affected Soil	Thickness	Volume
A	230′ x 30′	2′-7′	5′	1,280 yd^3
B	80′ x 30′	0′-5′	5′	450 yd^3
C	80′ x 30′	4′-7′	3′	270 yd^3

Discussion regarding the Soil excavation IRA conducted at Site 15 is provided in Section 3.1.2.1.

2.2.3.2 Groundwater

Table 1-2 presents laboratory data associated with the latest groundwater sampling event conducted in October 2009. The groundwater analytical data shows BEX concentrations below laboratory method reporting limits in 20 of the 30 monitoring wells. Concentrations of BEX above SCGs were present in MW-2, MW-11, MW-14, MW-15, MW-19, MW-22, MW-101, MW-103, MW-105, and MW-112.

Benzene concentrations in these ten wells ranged from ND to 49 µg/L. Figure 1-7 shows the lateral extent of benzene in groundwater in October 2009 using all 30 MW sampling locations and relative to the NYSDEC ambient groundwater quality standard of 1 µg/L (NYSDEC 1998). The highest concentration of benzene was found in the area immediately north of Molloy Road on the ANG property.

Figure 1-8 illustrates the distribution of dissolved ethylbenzene in October 2009 using all the 30 MW locations and relative to the NYSDEC ambient groundwater quality standard of 5 µg/L. Ethylbenzene concentrations in these ten wells ranged from ND to 380 µg/L. Ethylbenzene concentrations were highest in the vicinity of well MW-19 north of Molloy Road on the ANG property.

Figure 1-9 shows the distribution of dissolved xylenes in October 2009 using all 30 MW sampling locations and relative to the NYSDEC ambient groundwater quality standard of 5 µg/L. Xylene concentrations in these ten wells ranged from ND to 420 µg/L. Xylene concentrations were highest in the vicinity of well MW-19 north of Molloy Road on the ANG property.

As discussed in Section 2.2, Toluene and MTBE were not detected at concentrations above applicable SCGs in any of the wells sampled during the plume delineation investigations in February 2008 and October 2009, suggesting that toluene and MTBE are no longer compounds of potential concern at Site 15, BGC or the RamTech property.

Figure 2-1 depicts the extent of BEX-affected groundwater, the location of all monitoring wells, the ERP Site 15 soil removal IRA excavation limits, and PT injection points. Figure 2-1 shows that the extent of BEX-affected groundwater has been delineated on the Hancock ANGB property, BGC property, and on the RamTech property with the plume dissipating within the boundaries of the GE Property.

2.3 Remedial Action Objectives

The BEX contamination in groundwater at the 174th FW was described in Section 1.2. The results of the baseline risk assessment indicate that, due to the presence of dissolved BEX at concentrations above the NYSDEC Ambient Water Quality Standards, groundwater on-site and off-site of Site 15 presents an unacceptable potential future risk to human health under the reasonable maximum exposure scenario assumptions of NYSDEC Ambient Water Quality Standards (i.e., site groundwater used as drinking water). In this case, the risks are considered to be potential future risks because area groundwater is not currently used as a drinking water source. In addition, three areas were identified to contain BEX affected soil per the criteria discussed in Section 2.2.3.1.

To mitigate potential future health risks and ensure protection of groundwater resources, site-specific RAOs have been developed. These RAOs will serve as the performance objectives for remedial actions at the Site 15. The RAOs for the 174th FW are as follows.

2.3.1 Soil

Based on the evaluation discussed above and the final NYSDEC guidance regarding development of RAOs in DER-10 (NYSDEC 2002), the Site soil RAOs will be:

- SRAO1 - Prevent ingestion, direct contact, and/or inhalation of/with soil that poses a risk to public health and the environment given the intended use of the Site; and
- SRAO2 - Prevent inhalation of or exposure from COPCs volatilizing from soil that poses a risk to public health and the environment given the intended use of the Site.

2.3.2 Groundwater

Based on the evaluation discussed above and the final NYSDEC guidance regarding development of RAOs in DER-10 (NYSDEC 2002), the RAOs for on-site groundwater are:

- GWRAO1 - Prevent exposure to contaminated groundwater containing BEX concentrations above the NYSDEC Ambient Water Quality Standards and Guidance;
- GWRAO2 - Prevent or minimize further off-site migration of the contaminant plume (plume containment);
- GWRAO3 - Prevent or minimize further migration of contaminants from source materials to groundwater (source control);
- GWRAO4 - Enhance the natural process for the attenuation of BEX compounds on-site and off-site; and
- GWRAO5 - Prevent inhalation of or exposure from COPCs volatilizing from groundwater that poses a risk to public health and the environment given the intended use of the Site.

2.4 Identification and Screening of Remediation Technologies

This section screens a variety of remedial technologies that may be employed individually or in combination to achieve the RAOs for Site media of interest. Remedial technologies that pass the evaluation process are organized into remedial alternatives. The remedial action alternatives for the Site are then are presented and evaluated in detail in Sections 3.0 and 4.0.

The remedial technologies considered for media of interest are general engineering approaches that would rely on ex-situ, in-situ or institutional/containment types of response actions that could meet one or more of the RAOs. The considered technologies were identified through a review of NYSDEC information, EPA guidelines, relevant literature, off-site conditions, and experience in developing feasibility studies and remedial action plans for similar types of environmental conditions.

The identified technologies underwent a screening against the following criteria: effectiveness, implementability and ability to meet RAOs. The general response actions listed in Section 2.4 are subdivided by remediation technology types and process options and listed below.

Type	**Technology/Control**
Institutional Controls	Access and Use Restrictions
Ex-Situ Treatment	Excavation and Off-site Disposal
In-Situ Treatment	Enhanced Aerobic Bioremediation using Solid Peroxide
	Enhanced Aerobic Bioremediation using Air Sparging
	Enhanced Anaerobic Bioremediation
	In Situ Chemical Oxidation Using Permanganate
Natural Recovery	MNA of Off-site Groundwater
Other	Groundwater Monitoring

The rationales for retaining or eliminating particular technologies are provided in Table 2-4. Technologies determined to be inappropriate based on criteria of effectiveness, implementability, ability to meet RAOs are eliminated from further consideration.

Effectiveness considers how a technology would impact the Site in the short-term during its use and its ability to meet the RAOs in the long-term. Protection of human health and environment considers potential positive and adverse impacts that may result from the use of a particular technology. This evaluation incorporates elements of the NYSDEC guidance documents NYSDEC TAGM-4030 (NYSDEC 1990) and the final DER-10 (NYSDEC 1990; NYSDEC 2002) and the *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988).

The evaluation of implementability focused on institutional aspects associated with use of the remedial technology, along with constructability and operation and maintenance (O&M) requirements. These subcategories are consistent with the approach for remedial alternative evaluation in TAGM-4030 (NYSDEC 1990). Institutional aspects involve permits or access approvals for on-site use, off-site work, and off-site treatment, storage and disposal services. Constructability, or technical feasibility, refers to the ability to construct, reliably operate and meet technical specifications or criteria, and the availability of specific equipment and technical specialty personnel to operate necessary process units.

The evaluation of effectiveness, implementability and ability to meet RAOs further reduced the list of remedial technologies. Those exhibiting more favorable characteristics in the evaluated areas were carried forward. As shown in Table 2-4, four of the proposed remedial technologies for Site media of interest are carried forward for development of the remedial alternatives section. Based on the screening evaluation summarized in Table 2-4, the following technologies/process options are retained for the development of remedial alternatives, in addition to the "no action" response:

- Water use restrictions;
- Excavation and Off-Site Disposal of soil;
- MNA (Groundwater monitoring); and
- Aerobic Bioremediation with Solid Peroxide.

As aerobic bioremediation with solid peroxide was considered to be the most effective and implementable, as well as the most cost effective, active remedial action technology for impacted groundwater, it was retained and the others eliminated from moving forward to the alternatives analysis.

SECTION 3.0

DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

In this section, the remediation technologies that remain following the initial screening presented in Section 2.0 are combined to form potential remedial alternatives for addressing impacted media at the Site. The objective of this step of the FS is to develop remedial alternatives that are protective of human health and the environment and encompass a variety of response options, including:

- Control of potential exposure pathways;
- Reduction of the contaminant mass in impacted media;
- Reduction of risk to an acceptable level and prevention of potential off-site migration; or
- Some combination of the above.

In accordance with EPA guidance (1988), potential remedial alternatives are first developed, and then eliminated from further consideration if they:

1. Do not provide sufficient protection of human health and the environment (effectiveness criterion);
2. Are problematic with respect to technical or administrative feasibility (implementability criterion); or
3. Are significantly higher in cost than other alternatives without a corresponding increase in benefit, protection, or reliability (cost criterion).

Screening of potential alternatives using the above criteria typically results in a smaller, more manageable set of the most appropriate alternatives, which are then further evaluated in a detailed analysis (Section 4.0). The detailed analysis results in the selection of a preferred remedial alternative for the site.

3.1 Common Actions and Interim Remedial Actions

As discussed above, remedial action alternatives would be developed for soil and groundwater. Common Actions and IRAs have been developed that address one or more of these two media. Common Actions are designed to provide at least the minimum required protection of human health and the environment. IRAs are developed to address both emergency and non-emergency site conditions, which can be undertaken without extensive investigation and evaluation, to prevent, mitigate, or remedy environmental damage.

3.1.1 Common Action 1: Indoor Air Investigation

As part of the off-site investigations, ERM performed a soil vapor study adjacent to the RamTech Facility and along their southern boundary (Northern boundary of GE) to evaluate the potential for soil vapor intrusion issues for off-site buildings. Based on the evaluation of soil vapor and groundwater data collected in the vicinity of the RamTech building as discussed in Section 1.2.6.5 and presented in Table 1-3, ERM recommended that indoor air evaluation should be performed.

The objective of the recommended indoor air sampling is to identify the nature and extent of any potential VOCs detected in site soil vapors collected from beneath building foundations (i.e. sub-slab), in indoor air (collected from within the Site buildings) and ambient air (collected from exterior building locations). The sample results will enable NYSDEC and NYSDOH to: 1) compare indoor air concentrations with a corresponding concentration beneath the building, and 2) determine the effects of ambient “background” concentrations on the indoor air quality.

ERM will collect three types of samples: Indoor Air, Sub-Slab Vapor and Outdoor Air. Prior to the collection of the samples, an Indoor Air Quality Questionnaire will be completed for each indoor air sampling location.

ERM will sample two sub-slab and two indoor air locations within the RamTech Facility as recommended in ERM’s Final Technical Memorandum dated November 2009. The outdoor air samples will be collected concurrently with the collection of the indoor and sub-slab vapor samples.

For sub-slab vapor samples, a 1-inch diameter hole will be drilled approximately 1 to 2 inches into the concrete slab using an electric hammer drill. A ½-inch drill bit will be used to drill through the remaining thickness of the slab and approximately 3 inches into the sub-slab material. A section of 1-4-inch O.D. Teflon™ tubing will be installed to the bottom of the concrete slab. The annular space between the 1-inch hole and 1/4-inch tubing will be sealed with melted beeswax. Stainless steel washers will be placed around the Teflon™ tubing at the interface between the 1-inch and ½-inch hole to ensure that the beeswax did not enter the ½ -inch hole. An attempt will be made to locate the sub-slab vapor probe near the central portion of the slab away from the building edges. The Teflon™ tubing will be purged into a 60 cubic centimeter (cc) syringe; the syringe will be removed and capped so that the air purged from the tubing would not be released to the indoor air. The Teflon™ tubing will then attached to the sampling tube.

For indoor air samples the intake will be placed at breathing zone heights of approximately 3 to 5-ft above the floor. As practical, based on building features, the samples were typically collected in a central location away from outside windows or doors. At the time of retrieval any noticeable changes in the condition of the sampling area, such as open windows or doors, operation of the heating/ventilation system, or condition or location of items in proximity to the canister will be noted on the sampling form. Prior to sampling, a calibrated PID will be used to conduct VOC screening of the indoor air sample area. Indoor air samples will be collected in axial sorbent tube using a positive displacement pumping set up. Sorbent methodology uses EPA Method TO-17 to analyze soil vapor samples for the presence of VOCs and for this application the analytes will be limited to benzene, ethylbenzene and xylenes. TO-17 is an approved analytical method in the NYSDOH's "Guidance for Evaluating Soil Vapor Intrusion in the State of New York" dated October 2006. The pumps will run for a two hour sampling period and all Quality Assurance/Quality Control samples associated with the method will be collected. The resulting tube samples will be logged and transported under chain of custody to a certified laboratory.

This common action would address GWRAO5. If the results from the indoor air investigations indicate there is no risk to public health from inhalation of or exposure from VOCs volatilizing from groundwater, no further action will be recommended. However, there may be a need for an additional common action (i.e. sub-slab depressurization) contingent upon the results of this investigation.

3.1.2 Interim Remedial Actions

Two IRAs were conducted as part of the remedial actions. They are:

- ERP Site 15 source area soil removal and off-site disposal (work completed in August 2008); and
- Groundwater treatment ISCO PT using solid CaO_2 injections to enhance bioremediation (work completed in May 2009).

3.1.2.1 ERP Site 15 - Source Area Soil Removal

In August 2007, ERM conducted an additional Supplemental RI based on the findings of ERM's January 2007 Technical Memorandum (ERM 2007). The January 2007 Technical Memorandum (ERM 2007) concluded that there is a significant volume of residual petroleum-affected soil in the unsaturated zone in the source area of Site 15. The presence of this affected soil above the groundwater table would likely have a negative impact on the effectiveness of the planned groundwater remediation involving treatment only in the saturated zone. ERM recommended further investigation of residual petroleum in the unsaturated zone in the source area of Site 15.

As discussed in Section 2.2.3.1, the results of analytical testing, elevated PID readings, soil water agitation testing and discussions with ANG personnel were used to identify areas of petroleum-affected soil in the unsaturated zone at Site 15. Those areas were defined as Areas A, B, and C as shown in Figure 1-10. The estimated volume of petroleum-affected soil that ERM recommended to be removed prior to any enhanced bioremediation treatment of Site 15 groundwater was 2,000 cubic yards, or approximately 3,000 tons.

ERM prepared a Final Engineering Evaluation/Cost Analysis (EE/CA) for the ANG in June 2008, and the following three alternatives were developed to address removal action objectives for remediation of petroleum-affected soil in the source area at Site 15:

- Alternative 1 – No Action
- Alternative 2 – Soil Excavation and Off-Site Disposal
- Alternative 3 – Soil Excavation and On-Site Treatment

Alternative 2 (Soil Excavation and Off-Site Disposal) was the recommended removal action alternative. This alternative provides the most reliable long-term source control action and provides the most effective protection of human health and environment. This alternative is both technically and administratively implementable and requires no long-term maintenance or monitoring on the part of the individual residents. Alternative 2 was also the most cost effective and time critical active removal action evaluated.

A *Final Interim Remedial Action – Source Area Removal Work Plan* was submitted to the NYSDEC in July 2008. This plan presented the following:

- A summary of site conditions and results of applicable historical soil and groundwater investigation, and remediation activities;
- Development of RAOs for protection of human health and the environment; and
- An implementation plan for the chosen additional remedial measure.

The objective of this IRA was is to remediate soil impacted with COPCs to below the proposed NYSDEC Recommended SCOs. Using the protection of groundwater standard as the cleanup goals significantly decreased the potential risk to human health and the environment, and allowed the planned groundwater remediation involving treatment only in the saturated zone to be more effective.

Remedial activities included mobilization; excavation/stockpiling of non petroleum-affected soil; excavation/transportation/disposal of petroleum-affected soil (areas A, B, and C); confirmation and stockpile soil sampling; placement of Permeox – a slow release CaO_2 - within the excavations; backfilling of the excavations; and Site restoration. The majority of the field work was completed between 11 and 29 August 2008.

The applicable remedial standard for the soil excavation IRA was removal of grossly-affected soil as evaluated in the field using the field screening approach outlined in the Work Plan *A Final Interim Remedial Action – Source Area Removal Work Plan* (ERM 2008b).

Excavation, transportation and disposal of petroleum-affected soil were initiated by ERM's remediation contractor, Environmental Waste Minimization Inc. (EWMI), on 12 August 2008 and were completed on 26 August 2008. Petroleum-affected soils were transported to the Ontario County Landfill for use as a non-hazardous daily cover at their Stanley, New York facility. A total of 84 truck loads of petroleum-affected soil (approximately 2,890 tons) were removed from the site.

Based on Work Plan details, the final excavation depth had been estimated approximately 1-foot above the lowest average groundwater depth. For excavation and design/planning purposes, the average groundwater depth was 8 ft bgs. Depth and extent of excavation was determined in the field by ERM's Construction Manager using a PID, sheen testing, visual observations and confirmation sampling. Excavations A and C had final bottom depths that ranged from 7 to 9.5-ft bgs. Excavation B had a final bottom depth generally around 5-ft bgs. The excavation areas were completed to the lateral limits indicated in Figure 1-11.

After the excavation was finished, confirmation sampling was performed. For ERP Site 15, soil confirmation samples were collected from excavation sidewalls and from the excavation floors. As per the requirements of NYSDEC final DER-10, Section 5.4(a)2.iii., confirmation soil samples were collected from the excavation sidewalls at approximately 50 foot linear intervals, and for approximately every 1,200 square ft at the bottom of the excavation. Sidewall samples were obtained at the midpoint of the area of excavated impacted soil. The confirmation sample locations are presented on Figure 1-12.

Confirmation sampling results as shown in Table 3-1. Results indicate that the constituents of concern concentrations in residual soil are below NYSDEC Part 375 cleanup levels in 25 of the 32 samples. Of the 7 samples that exhibited concentrations above the cleanup levels, 6 samples were collected from the floor of the excavation where no additional excavation was performed due to the presence of groundwater and/or the area was treated with the PermeOx® Plus, an oxygen release material (ORM) prior to backfilling, as discussed below. Based on adjacent boring information and application of ORM to the bottom of the excavation, ERM considers the vertical extent of excavation to be completed.

The one wall sample that exhibited concentrations above the cleanup levels, SC-16, contained ethylbenzene at a concentration of 1,800 micrograms per kilogram. The cleanup standard for ethylbenzene is 1,000 micrograms per kilogram. Based on adjacent boring information, previous PID reading, treatment of residual contamination as discussed below and discussions with the NYSDEC pertaining to this sample location, ERM considers the horizontal extent of excavation to be completed. NYSDEC verbally accepted ERM's conclusions that both the vertical and horizontal extent of ERP Site 15 source area has been addressed in this IRA.

Concentrations of chemicals in excess of the soil standards were treated with the following volumes of the chemical equivalent of PermeOx® Plus, an ORM. The following amounts were applied within each excavation area:

- Excavation Area A – 2,880 pounds;
- Excavation Area B – 960 pounds; and
- Excavation Area C – 960 pounds.

Upon completion of the placement of the ORM material in each excavation, backfill and compaction operations were performed to bring each excavation to grade and site restoration was performed with the addition of seed and hay.

More detailed discussions are presented in the *Site 15 Final Construction Completion Report - Source Area Soil Removal* dated January 2009 (ERM 2009a).

3.1.2.2 Enhanced Bioremediation In-Situ Chemical Oxidation Pilot Test

ERM prepared and submitted the *Site 15 Supplemental RI/PT Work Plan* in October 2008 (ERM 2008c). ERM conducted an enhanced natural attenuation PT via ISCO southwest of the RamTech facility, west of along Fairway Drive, north and south Molloy Road to evaluate the effectiveness of enhanced natural attenuation within the BEX-plume.

As a first step, "baseline" round of groundwater sampling from select monitoring wells adjacent and down-gradient of the PT area were sampled prior to performing the PT. On 13 April 2009, the following monitoring wells were sampled: MW-19, MW-105, MW-106, MW-107, MW-111 and MW-112. The wells were sampled in conformance with EPA low-flow (minimal drawdown) well purging and sample collection techniques (EPA 1996). In addition, during the "baseline" groundwater sampling event, the select monitoring wells were also analyzed for natural attenuation parameters to evaluate the performance of the PT. Analytical data for the pre-treatment rounds are summarized in Table 3-2 along with a comparison the NYSDEC standards for groundwater.

The goal of the PT was to decrease the concentrations of BEX in groundwater, and to prevent further migration of the BEX plume onto off-site property. The CaO_2 slurry was injected into the saturated zone within the BEX plume during the PT. The introduction of CaO_2 provides a controlled release of oxygen which permeates throughout the substrate enhancing microbial activity which biodegrades BEX compounds.

Approximately 20 injection points were installed over a period of 4 days during the week of 11 May 2009 using direct-push technology in the locations depicted on Figure 1-13. Each injection point was advanced to the bottom of the targeted injection zone within the predominately sand geologic unit (approximately 15 to 30 ft bgs), where BEX has historically been observed in groundwater. A maximum of 50 pounds of CaO_2 was injected at each location. Injection of the CaO_2 started on the northern most injection area on ANG property and move southward.

On 5 August 2009 approximately 12-weeks after CaO_2 injection, the following monitoring wells were sampled: MW-19, MW-105, MW-106, MW-107, MW-111, MW-112, MW-113, and MW-114 (Note: MW-113 and MW-114 are sentinel wells installed after the injection process). The wells were sampled in general conformance with EPA low-flow (minimal drawdown) well purging and sample collection techniques (EPA 1996). Analytical data are summarized in Table 3-2 along with the NYSDEC standards for groundwater. BEX compounds were not detected in five of the eight groundwater samples (MW-106, MW-107, MW-112, MW-113, and MW-114). The concentration of benzene (6.0, 3.3 and 6.9 µg/L), ethylbenzene (410 and 300 µg/L) and xylene (760 and 170 µg/L) in groundwater samples collected from MW-19, MW-105, and MW-112 exceeded the NYSDEC ambient groundwater quality standards of 1 µg/L, 5 µg/L, and 5 µg/L, respectively.

These eight wells were sampled again during the week of 5 October 2009 as part of site-wide groundwater sampling. Analytical data are summarized in Table 3-2 along with the NYSDEC standards and guidance values for groundwater. BEX compounds were not detected in five of the eight groundwater samples (MW-106, MW-107, MW-112, MW-113, and MW-114). The concentration of benzene (<10, 16 and <10 µg/L), ethylbenzene (380, 8.6 and 48 µg/L) and xylene (420, 14 and <20 µg/L) in groundwater samples collected from MW-19, MW-105, and MW-112 exceeded the NYSDEC ambient groundwater quality standards of 1 µg/L, 5 µg/L, and 5 µg/L, respectively. This sampling was conducted approximately 20-weeks after the CaO_2 PT injections.

Review of these data indicates that the injection of CaO_2 slurry, in general, enhanced the natural attenuation process. Concentrations of ethylbenzene and xylenes decreased to below the NYSDEC ambient groundwater quality standards in MW-105 by the August sampling event and still remained over 10-fold lower in October 2009 than the concentrations at the baseline sampling event prior to the PT injection. At MW-112, concentrations of ethylbenzene and xylene were decreased over six-fold in October than at the baseline sampling event. Benzene concentrations, although slightly higher than at the baseline sampling event, remained below historical concentrations at both wells.

Concentrations of BEX at MW-19, which had been at historically low concentrations in February 2009 and at the baseline sampling event, showed increases at the August and October 2009 sampling events. These observations may be due to the August 2009 excavation activities, which may have resulted in the release of some BEX mass to groundwater. The oxygen that was delivered during the PT test may have been insufficient to attenuate this mass. Comparison of the concentration data between August and October indicate a decreasing trend.

The overall conclusions are that the injection of CaO_2 slurry enhanced natural attenuation within the plume, that the loading of CaO_2 slurry was sufficient in the down gradient portion of plume, but that the loading of CaO_2 slurry was insufficient near Molloy Road to significantly decrease the mass flux closer to the former source area. These observations will be incorporated into designs for remediation Alternatives 3 and 4.

3.2 Development of Alternatives

Four potential alternatives for the Site 15 media of interest were developed using the technologies that remained after the initial screening (Table 2-4). These alternatives are based on the current understanding of the BEX distribution in groundwater and soil at Site 15. The four remedial alternatives are outlined below:

- Alternative 1: No Action. This alternative would leave the site in its present condition. No actions would be taken to monitor groundwater, prevent human contact, prevent contaminant migration, or mitigate the contaminants.

- Alternative 2: Source Removal and MNA. Alternative 2 utilizes excavation and off-site disposal of the source areas and MNA as the primary treatment methods.

- Alternative 3: Source Removal and Focused Enhanced Aerobic Bioremediation with MNA. In Alternative 3, the primary treatment utilizes excavation and off-site disposal of the source areas, targeted aerobic bioremediation to prevent further off-site migration and MNA as the primary treatment methods.

- Alternative 4: Source Removal and Expanded Enhanced Aerobic Bioremediation with MNA. In Alternative 4, the primary treatment utilizes excavation and off-site disposal of the source areas, aerobic bioremediation of the plume site wide (on-site and off-site) using solid peroxide and MNA as the primary treatment methods.

3.3 Screening of Alternatives

A list of current wells that will be gauged and sampled by ERM, including above and screens each alternative with respect to criteria of effectiveness, implementability, and cost. The factors considered in assessing each of these criteria include:

- Effectiveness
    - Protection of human health and the environment
    - Compliance with RAOs
    - Reduction in contaminant TMV through treatment
- Implementability
    - Technical feasibility
    - Availability of technology and expertise
    - Administrative approval
- Cost
    - Capital costs
    - O&M costs

3.3.1 Alternative 1: No Action

Description. The No Action alternative assumes that no active treatment measures, site modifications, groundwater monitoring, or other actions would be undertaken to prevent or eliminate human health and environmental risks associated with impacted media.

Evaluation. This alternative does not meet the effectiveness criterion, as it includes no measures to protect human health and the environment, comply with RAOs, or reduce contaminant TMV, except through unmonitored natural attenuation processes. The only protection to human health would be the mandatory enforcement of Part 5 of the NYSDOH State Sanitary Code, which prevents installation of a private potable water supply well in areas that are served by a public water supply system. This would prevent potable water consumption of affected Site groundwater. However, the No Action alternative is a required component of the EPA FS process and thus is retained as a baseline for comparison against the other alternatives (see Section 4.0).

3.3.2 Alternative 2: Source Removal with Monitored Natural Attenuation

Description. Alternative 2 utilizes excavation and off-site disposal of the source areas and MNA as the primary treatment methods. Based on the observed BEX concentrations, the duration of this alternative is expected to range from up to 30 years.

Implementation of Alternative 2 at the Site would involve:

- Use restrictions: Part 5 of the NYSDOH State Sanitary Code, which prevents installation of a private potable water supply well in areas that are served by a public water supply system, would continue to be enforced. This would prevent future use of the BEX affected groundwater as drinking water.

- Implementation of Common Action No. 1: Indoor Air investigation at the Ramtech Property ;

- Implementation of the excavation IRA: Excavation and disposal of the identified source area. This portion of Alternative 2 has already been completed as an IRA as described in Section 3.1.2.1; and

- Monitoring BEX concentrations and natural attenuation parameters in shallow groundwater quarterly for 5 years and annually for up to 30 years.

Monitoring of VOCs would be performed to verify that concentrations are decreasing with time. A decreasing trend in VOC concentrations throughout the area of contamination would indicate that the TMV of the COPCs are decreasing and that VOC plume is not continuing to expand. Monitoring of natural attenuation parameters would be conducted to verify that VOCs are biodegrading and to estimate the rate of intrinsic bioremediation.

Costs associated with Alternative 2 are presented in Table 3-3.

Evaluation. This alternative meets the criteria of implementability and cost, but does not meet the criteria for effectiveness, since based on discussions in Section 2.2.2, the rate at which attenuation is occurring has been insufficient to contain the plume on site and decrease concentrations across the plume. Therefore, this alternative is not retained for further evaluation.

3.3.3 Alternative 3: Source Removal and Focused Enhanced Aerobic Bioremediation with MNA

Description. In Alternative 3, the primary treatment utilizes excavation and off-site disposal of the source areas, aerobic bioremediation to prevent further off-site migration and MNA as the primary treatment methods.

Implementation of Alternative 3 at the site would involve:

- Use restrictions: Part 5 of the NYSDOH State Sanitary Code, which prevents installation of a private potable water supply well in areas that are served by a public water supply system, would continue to be enforced. This would prevent future use of the BEX affected groundwater as drinking water;

- Implementation of Common Action No. 1: Indoor Air investigation at the Ramtech Property ;

- Implementation of the two IRAs:

    - Excavation and disposal of the identified source area. This portion of Alternative 3 has already been completed as an IRA as described in Section 3.1.2.1; and

    - Enhanced Bioremediation Pilot Study already completed as described in Section 3.1.2.2 to evaluate effectiveness of enhanced bioremediation, spacing of the injection points and peroxide loading.

- Installation of aerobic biological treatment barriers primarily along Molloy Road and Fairway Drive to control off-site migration of VOCs; approximately 43 injection points would be installed using direct-push techniques with a maximum of 50 pounds of solid peroxide injected at each injection location; the barriers would consist of rows of direct-push injection points, with 20 ft spacing as determined during the PT. Figure 3-1 depicts conceptual design injection locations for this alternative;

- Monitoring BEX concentrations and natural attenuation parameters in shallow groundwater conducted quarterly for 4 years and annually for up to 10 years; and
- Since solid peroxide generally persists for 1 to 3 years after injection, additional injections of solid peroxide will be required at Year 2 at 50% of the original injection locations with a maximum of 50 pounds of solid peroxide injected at each injection location; the number of injection points will be fewer than the first injection event, since the attenuation of the plume is expected to accelerate due to the flux reduction resulting from the source area removal action and the initial peroxide injections. For cost estimation purposes it has been assumed that follow-up injections in approximately 50% of the 43 original locations (i.e., 22 locations) will be required at Year 2.

Costs associated with Alternative 3 are presented in Table 3-4.

Evaluation. This alternative meets the criteria of effectiveness, implementability, and cost, and is, therefore, retained for further evaluation.

3.3.4 Alternative 4: Source Removal and Expanded Enhanced Aerobic Bioremediation with MNA

Description. In Alternative 4, the primary treatment utilizes excavation and off-site disposal of the source areas, aerobic bioremediation of the plume site wide using solid peroxide and MNA as the primary treatment methods.

Implementation of Alternative 4 at the site would involve:

- Use restrictions: Part 5 of the NYSDOH State Sanitary Code, which prevents installation of a private potable water supply well in areas that are served by a public water supply system, would continue to be enforced. This would prevent future use of the BEX affected groundwater as drinking water;
- Implementation of Common Action No. 1: Indoor Air investigation at the Ramtech Property;
- Implementation of the two IRAs:

  - Excavation and disposal of the identified source area. This portion of Alternative 4 has already been completed as an IRA as described in Section 3.1.2.1; and

  - Enhanced Bioremediation Pilot Study already completed as described in Section 3.1.2.2 to evaluate effectiveness of enhanced bioremediation, spacing of the injection points and peroxide loading.

- Injection of a slurry of solid peroxide into rows of direct push points located within both on-site and accessible off-site areas of the plume that are currently above RAOs. The released oxygen will enhance aerobic biodegradation and as concentrations of VOCs decrease over time, the treatment area will be reduced. Assuming an inter-well spacing within rows of 20 ft and 12 rows of points (7 on-site and 5 off-site), approximately 106 injection points will be required to address areas of the plume after excavation. Figure 3-2 depicts conceptual design injection locations for this alternative;

- Monitoring VOC concentrations and natural attenuation parameters in shallow groundwater quarterly for 3 years during active remediation and annually for up to 10 years; and

- Since solid peroxide generally persists for 1 to 3 years after injection, additional injections of solid peroxide will be required at Year 2 at 53 of the original injection locations with a maximum of 50 pounds of solid peroxide injected at each injection location; the number of injection points will be fewer than the first injection event, since the attenuation of the plume is expected to accelerate due to the flux reduction resulting from the source area removal action and the initial peroxide injections. For cost estimation purposes it has been assumed that follow-up injections in approximately 50% of the 106 original locations (i.e. 50 locations) will be required at Year 2.

Costs associated with Alternative 4 are presented in Table 3-5.

Evaluation. This alternative meets the criteria of effectiveness, implementability, and cost, and is, therefore, retained for further evaluation.

SECTION 4.0

DETAILED ANALYSIS OF ALTERNATIVES

This section presents a detailed analysis of the remedial alternatives developed and screened in Section 3.0 in accordance with the *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988) and NYSDEC's Final DER-10 (NYSDEC 2002). Finally, the alternatives are collectively evaluated against the criteria through a comparative analysis, and a preferred alternative is selected.

4.1 Evaluation Criteria

The seven criteria used to evaluate the remedial alternatives are listed below:

- Overall protection of human health and the environment;
- Compliance with SCGs;
- Long-term effectiveness and permanence;
- Reduction of TMV;
- Short-term effectiveness;
- Implementability; and
- Cost.

The first two criteria, overall protection of human health and the environment and compliance with SCGs, are considered threshold criteria. Consequently, there is an expectation that each selected remedial action alternative would achieve these two criteria.

The next five evaluation criteria are referred to as balancing criteria. They offer a basis to compare the remedial action alternatives as part of the decision-making process that results in a recommended remedial action alternative. A discussion of each evaluation criteria follows.

4.1.1 Overall Protection of Human Health and the Environment

This criterion is used to assess whether a remedial alternative provides sufficient protection of human health and the environment. The assessment of overall protection considers the degree to which an alternative satisfies the requirements of the other evaluation criteria, particularly compliance with SCGs presented in Table 2-1, long term effectiveness and permanence, and short-term effectiveness. Evaluation against this criterion includes consideration of whether an alternative poses any unacceptable short-term or cross-media impacts.

4.1.2 Compliance with Standards, Criteria, or Guidelines

This criterion is used to assess whether an alternative will satisfy the SCGs applicable to the Site. The primary SCGs applicable to the remediation of groundwater and soil at the Site are discussed in Table 2-1.

4.1.3 Long-Term Effectiveness and Permanence

The long term effectiveness and permanence of a remedial alternative is evaluated considering the risks remaining at the site after the remedial goals have been met. The evaluation considers four major factors:

- The magnitude of residual risk to human and environmental receptors remaining from untreated waste or treatment residues at the completion of remedial activities;

- The type, degree, and adequacy of long term management required for untreated waste or treatment residues remaining at the site;

- The long-term reliability of engineering and/or institutional controls for providing continued protection from untreated waste or treatment residues; and

- The potential need for replacement of the remedy, and the continuing need for repairs to maintain the performance of the remedy.

4.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the degree to which a remedial alternative employs treatment technologies that permanently and significantly reduce the TMV of the hazardous substance(s). The evaluation considers the following factors:

- Treatment processes;
- The amount of hazardous materials that will be treated;
- The degree of expected reduction in TMV, including how the principal threat is addressed through treatment;
- The degree to which the treatment will be irreversible; and
- The type and quantity of treatment residuals that will remain following treatment.

4.1.5 Short-Term Effectiveness

The short-term effectiveness of a remedial alternative is evaluated relative to its effect on human health and the environment during implementation of the alternative. The evaluation considers the following factors:

- Short-term risks that might be posed to the community during implementation of an alternative;
- Potential impacts on workers during implementation, and the effectiveness and reliability of protective measures;
- Potential environmental impacts during implementation, and the effectiveness and reliability of mitigative measures; and
- The length of time required to achieve RAOs.

4.1.6 Implementability

Implementability refers to the technical, administrative, and environmental feasibility of implementing an alternative, and the availability of various materials and services required during its implementation.

The following factors are used to assess implementability:

- Practical, technical, and legal difficulties or unknowns associated with the construction and implementation of a technology, engineering control, or institutional control, including potential scheduling delays;
- The ability to monitor the effectiveness of the remedy;
- Consistency with Federal, State, and local requirements; the activities needed to coordinate with other agencies; and the ability and time required to obtain any necessary authorization from other governmental bodies; and
- The availability of necessary services, materials, equipment, and specialists, including the availability of prospective technologies and adequate off-site treatment, storage, and disposal capacity and services.

4.1.7 Cost

The cost estimates are presented in Tables 3-3, 3-4, and 3-5. The costs are based on the preliminary conceptual designs described in Section 3.0, and are expressed in terms of year 2009 dollars.

Changes in the quantities of the media requiring remediation (e.g., extent of soil and groundwater affected areas), detailed engineering, as well as other factors not foreseen at the time this report was prepared, could increase costs by as much as 50% or decrease costs by as much as 30%, as defined the *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988).

An inflation rate of 2% was used to determine future costs and an interest rate of 7% was used to compute the present worth of all future costs. The assumed interest rate, which corresponds to the current interest rate for a 30-year treasury bond, was selected to “produce an amount at which the environmental liability theoretically could be settled in an arm's length transaction with a third party, or if such a rate is not readily determinable, the discount should not exceed the interest rate on “risk-free” monetary assets with maturities comparable to the environmental liability” in accordance with the US Securities and Exchange Commission Staff Accounting Bulletin No. 92. Staff Accounting Bulletin No. 92 provides generally accepted accounting principles for estimating and reporting environmental liability.

The costs considered for each alternative included:

- Capital costs, including both direct and indirect costs;
- Annual O&M costs;
- Costs of any periodic review requirements; and
- Net present value of all of the above.

4.2 Individual Analysis of Alternatives

In this section, each of the remedial alternatives developed for the Site is evaluated against the criteria described in Section 4.1. The screened remedial alternatives evaluated are described in Section 3.0 and include:

- Alternative 1: No Action.
- Alternative 3: Source Removal and Focused Enhanced Aerobic Bioremediation with MNA.
- Alternative 4: Source Removal and Expanded Enhanced Aerobic Bioremediation with MNA.

Note that Alternative 2 was not screened for further evaluation in Section 3.3.2 as it would not meet the groundwater RAOs.

4.2.1 Alternative 1: No Action

This alternative would leave the site in its present condition. No actions would be taken to monitor groundwater, prevent human contact, prevent contaminant migration, or mitigate the contaminants.

Overall Protection of Human Health and the Environment. The No Action Alternative would not be protective of human health and the environment in the short term, because the potential risks associated with Site media would not be reduced or monitored, either through treatment, institutional controls, or groundwater monitoring. The only protection to human health would be the mandatory enforcement of Part 5 of the NYSDOH State Sanitary Code, which prevents installation of a private potable water supply well in areas that are served by a public water supply system. This would prevent potable water consumption of affected groundwater.

Compliance with SCGs. The No Action Alternative does not meet chemical-specific SCGs. As discussed in Section 2.2, BEX concentrations already exceed the NYSDEC Class GA ambient groundwater quality standards (TOGS-1.1.1; NYSDEC 1998), and although those concentrations could eventually decrease to levels below SCGs due to natural processes, these processes may not occur within a reasonable timeframe. Furthermore, the No Action Alternative does not include provisions for monitoring the progress of natural attenuation.

In addition, three BEX compounds exceed NYSDEC Part 375 SCOs for the protection of Groundwater and the No Action Alternative would not include soil removal of the identified source areas, or engineering controls. Specifically it would not comply with the following DER-10 remedial goal for the Site "where an identifiable source of contamination exists at a site, it should be removed or eliminated to the extent feasible, regardless of the presumed risk or intended use of the site" or with potential soil vapor intrusion issues should any building be built within the soil impacted areas in the future.

Long-Term Effectiveness and Permanence. The No Action Alternative does not provide long-term effectiveness and permanence because a residual risk to human health from BEX compounds in Site media could remain indefinitely. With no provision for monitoring, this alternative offers no means of evaluating residual risk.

Reduction of TMV. The No Action alternative does not include any treatment to reduce contaminant TMV. As discussed in Section 1.2.6 and Section 2.2.3.2, the contaminant plume has already migrated off-site. The natural degradation process occurs too slowly, and the volume of contaminated groundwater could further increase via contaminant migration.

Short-Term Effectiveness. As no actions are being conducted, the alternative would not create new short-term concerns.

Implementability. As there are no specific actions related to this alternative, the No Action Alternative would not present implementation obstacles. In addition, there are no O&M requirements for this alternative.

Cost. No costs would be associated with implementing the No Action Alternative.

4.2.2 Alternative 3: Source Removal and Focused Enhanced Aerobic Bioremediation with MNA

In Alternative 3, the primary treatment utilizes excavation and off-site disposal of the source areas, aerobic bioremediation primarily of the off-site plume to prevent further off-site migration and MNA as the primary treatment methods.

Overall Protection of Human Health and the Environment. The installation of aerobic biodegradation barriers targeting off-Site migration pathways is expected to effectively remove or significantly reduce the concentrations of BEX in the off-site groundwater and prevent further off-site migration. Furthermore, based on the 2009 groundwater investigation results described in Section 1.2.6.5, the plume is dissipating within the GE property and the PT preliminary results indicate that the CaO_2 injections enhance natural attenuation within the plume. Therefore, the risks associated with off-site exposure to impacted groundwater would be reduced to an acceptable level within a reasonable timeframe.

Under this Alternative, the up gradient portion of on-site impacted groundwater would not be actively treated other than through removal of source areas and MNA; however, the Site groundwater is not currently used for any purpose and exposure to groundwater presenting an unacceptable risk will be prevented through institutional controls. There may be potential risk posed to construction workers but these could be addressed through direct contact controls.

Excavation of the impacted soil, which has been conducted as an IRA, has offered protection from direct contact with impacted soil and has eliminated the potential for soil vapor migration from the impacted source area soils.

The enhanced natural attenuation in conjunction with the indoor air investigation (Common Action 1) will address potential risks derived from potential soil vapor migration from impacted groundwater at off-site buildings (Ramtech Property).

Compliance with SCGs. Alternative 3 would not actively treat the up gradient portion of on-site impacted groundwater; therefore, it would not meet chemical specific SCGs for on-site groundwater in the short term because a number of BEX compounds already exceed NYSDEC's Class GA ambient groundwater quality standards (TOGS-1.1.1; NYSDEC 1998). However, given the current on-site plume BEX concentrations, those concentrations could eventually decrease to levels below SCGs within a reasonable timeframe due to natural processes since source removal has been completed. Active treatment of the off-site plume is expected to comply with GWRAO2 and with GWRAO4 (since it would prevent further off-site migration and rely on natural processes for on-site BEX). In addition, the active treatment of the off-site plume coupled with the indoor air investigation (Common Action 1) will comply with GWRAO5.

Alternative 3 would meet the chemical-specific SCGs for soil as it would eliminate the identified source areas and further migration of soil contaminants to groundwater.

Long-Term Effectiveness and Permanence. The residual risk posed by off-site impacted groundwater would be reduced by this alternative because dissolved VOCs would be destroyed by oxidation. The water-use restrictions included as part of this alternative should be reliable in the long term for the on-site impacted groundwater, based on the current and anticipated future land use of the site (i.e., commercial). Attainment of RAOs would be verified through groundwater monitoring. Reduction in further off-site and the Site's VOC concentrations is expected to be achieved within 2 to 4 years of implementation.

Reduction of TMV through Treatment. The use of solid peroxide (either PermeOx® Plus or ORC-Advanced) oxidation focused primarily on an off-site area followed by MNA will result in reduced contaminant TMV primarily in the solid peroxide treatment areas and will prevent down gradient flux of contaminants. This reduction is achieved through chemical and biological destruction rather than transfer of contaminants from one medium to another. The treatment process is irreversible and will result in the production of harmless byproducts. Reduction in TMV chemicals in the Site soil source areas would occur through excavation and off-site disposal. Reduction of TMV chemicals on the up gradient portion of on-site impacted groundwater would mostly occur through natural attenuation processes enhanced by the removal of the source areas.

Short-Term Effectiveness. Implementation of this alternative would require worker handling of solid peroxide in solid or dissolved form. Worker exposure would be minimized by the use of appropriate health and safety personal protective equipment.

Adverse effects on groundwater from solid peroxide injection are not expected. The oxidative effects of the solid peroxide will diminish with time as it reacts with organic material in the subsurface.

Implementability. The equipment and construction methods required for the injection of peroxide slurry through wells or direct-push points are readily available and easily implemented. Preferential flow paths and areas of low conductivity may limit the ability to distribute the peroxide slurry radially away from the injection point and the solid peroxide may need to be injected more frequently than projected by vendors (once every 2 to 3 years). This technology can also be easily scaled up to treat additional areas or scaled down as the plume shrinks over time.

The identified source areas are easily accessible for excavation and off-site disposal. The Site's monitoring wells will ensure the ability to monitor the effectiveness of this alternative.

Obtaining access agreements with off-site plume property owners to complete the peroxide slurry injections may pose an implementability issue, however, the proposed injection locations for this alternative are located within properties that have granted ERM access during prior investigation phases, and therefore, implementability is not expected to be an issue of significance for this alternative.

Cost. Capital and O&M costs associated with Alternative 3 are detailed in Table 3-4.

4.2.3 Alternative 4: Source Removal and Expanded Enhanced Aerobic Bioremediation with MNA

In Alternative 4, the primary treatment utilizes excavation and off-site disposal of the source areas, aerobic bioremediation of the plume site-wide using solid peroxide and MNA as the primary treatment methods.

Overall Protection of Human Health and the Environment. Alternative 4 is expected to effectively remove or significantly reduce the concentrations of impacted groundwater both on- and off-site given the increased number of points 106 compared to Alternative 3. The 2009 groundwater investigation results described in Section 1.2.6.5 indicate that the plume is dissipating within the GE property and the PT preliminary results indicate that the CaO_2 injections enhance natural attenuation within the plume. Therefore, the risks associated with exposure to impacted groundwater would be reduced to an acceptable level within a reasonable timeframe based on the current and anticipated future land use.

Excavation of the impacted soil would offer protection from direct contact with impacted soil and would eliminate the potential for soil vapor migration from the impacted source area soils.

The enhanced natural attenuation in conjunction with the indoor air investigation (Common Action 1) will address potential risks derived from potential soil vapor migration from impacted groundwater at off-site buildings (Ramtech Property).

<u>Compliance with SCGs.</u> This alternative is expected to effectively reduce within a reasonable timeframe the concentrations of BEX compounds in groundwater to below the NYSDEC Class GA groundwater standards. Active treatment of the off-site plume is expected to comply with GWRAO2 and with GWRAO4. In addition, the active treatment of the plume coupled with the indoor air investigation (Common Action 1) will comply with GWRAO5.

This Alternative would meet the chemical-specific SCGs for soil as it would eliminate the identified source areas and further migration of soil contaminants to groundwater.

<u>Long-Term Effectiveness and Permanence.</u> The residual risk posed by groundwater on and off-site would be reduced by this alternative because dissolved VOCs would be destroyed by oxidation. Attainment of RAOs would be verified through groundwater monitoring. Soil impacts will be permanently eliminated through excavation and off-site disposal.

Risks associated with BEX in groundwater are expected to be reduced due to the rapid treatment resulting from in situ oxidation. Reduction in further off-site migration is expected to be achieved within 1 to 2 years and reduction of the site-wide VOC concentrations is expected to be achieved within 2 years of implementation.

<u>Reduction of TMV through Treatment.</u> The use of solid peroxide (either PermeOx® Plus or ORC-Advanced) oxidation site wide followed by MNA will result in reduced contaminant TMV both on-site and off-site and will prevent down gradient flux of contaminants. This reduction is achieved through chemical and biological destruction rather than transfer of contaminants from one medium to another. The treatment process is irreversible and will result in the production of harmless byproducts. Reduction in TMV chemicals in the Site soil source areas would occur through excavation and off-site disposal.

Short-Term Effectiveness. Implementation of this alternative would require worker handling of solid peroxide in solid or dissolved form. Worker exposure would be minimized by the use of appropriate health and safety personal protective equipment.

Adverse effects on groundwater from solid peroxide injection are not expected. The oxidative effects of the solid peroxide will diminish with time as it reacts with organic material in the subsurface.

Implementability. The equipment and construction methods required for the injection of peroxide slurry through wells or direct-push points are readily available and easily implemented. Preferential flow paths and areas of low conductivity may limit the ability to distribute the peroxide slurry radially away from the injection point and the solid peroxide may need to be injected more frequently than projected by vendors (once every 2 to 3 years). This technology can also be easily scaled up to treat additional areas or scaled down as the plume shrinks over time.

The identified source areas are easily accessible for excavation and off-site disposal. The Site's monitoring wells will ensure the ability to monitor the effectiveness of this alternative.

Obtaining access agreements with off-site plume property owners to complete the peroxide slurry injections may pose an implementability issue, however, the proposed injection locations for this alternative are located within properties that have granted ERM access during prior investigation phases, and therefore, implementability is not expected to be an issue of significance for this alternative.

Cost. Capital and O&M costs associated with Alternative 4 are summarized in Table 3-5.

4.3 Comparative Analysis of Alternatives

In the previous section, the three remedial alternatives that passed the screening were evaluated with respect to: overall protection of human health and the environment; compliance with SCGs; long-term effectiveness and permanence; reduction of TMV through treatment; short term effectiveness; implementability; and cost. In this section, the alternatives are compared to each other and rated based on how well each satisfies the evaluation criteria.

4.3.1 Overall Protection of Human Health and the Environment

All of the alternatives are equally protective in the near term since groundwater at the Site and in the vicinity of the Site is not currently used for drinking water or any other potable purposes based on the results of the well search. Therefore, the most protective alternative would be that which most reliably, completely, and quickly removes BEX from groundwater.

Alternative 1 (No Action) is not expected to reliably or quickly remove VOCs from site and off-site groundwater.

Alternatives 3 and 4 are expected to reliably and quickly reduce VOC concentrations in groundwater (through solid peroxide bioremediation) and impacted soil (through excavation). Solid peroxide bioremediation technologies have been used successfully in similar applications and both alternatives offer protection of human health and the environment.

Alternative 3 involves application of active treatment targeting the migration pathway mainly in the off-site plume area, and relies on institutional controls and natural attenuation processes for the protection of human health and the environment in the on-site impacted groundwater. Alternative 4 has been designed to actively treat all BEX-impacted areas on and off-site. As there are currently no exposures to either on-site or off-site groundwater, Alternatives 3 and 4 are equally protective of human health and the environment.

4.3.2 Compliance with Standards, Criteria, or Guidelines

Alternative 1 is not expected to reduce the chemical-specific SCGs for the impacted groundwater within a reasonable timeframe.

Both Alternatives 3 and 4 are expected to reduce chemical concentrations to below the chemical-specific SCGs for the impacted groundwater and soil within a reasonable timeframe. Alternative 3 focuses its treatment on the off-site plume migration pathway with some on-site treatment. Reduction of further on-site and off-site and the Site's VOC concentrations is expected to be achieved within 2 to 4 years of implementation. Alternative 4 actively treats on- and off-site groundwater and reduction of further off-site migration is expected to be achieved within 1 to 2 years and reduction of the site-wide VOC concentrations is expected to be achieved within 2 years of implementation.

4.3.3 Long-Term Effectiveness and Permanence

Alternative 1 does not provide long-term effectiveness, since no measures are taken to reduce or monitor concentrations of VOCs in groundwater or to remove soil impacts.

Alternatives 3 and 4 both provide long term protectiveness, since both alternatives will permanently reduce VOCs concentrations and achieve RAOs through excavation, solid peroxide bioremediation and natural attenuation. However, Alternative 4 is expected to provide the most reliable long-term effectiveness as in-situ bioremediation is applied the most aggressively throughout the whole impacted plume.

4.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 will not significantly reduce the TMV impacted groundwater at the Site within a reasonable timeframe. Some reduction of toxicity may occur through natural attenuation; however, this alternative does not include measures to monitor this reduction, or to ensure that the mobility and/or volume of contaminated groundwater does not increase.

Alternatives 3 and 4 are expected to effectively reduce the TMV of contaminated groundwater at the Site through direct oxidation and natural attenuation. Alternative 4 is expected to be more effective than Alternative 3 in reducing contaminant TMV, due to the expanded provisions for biodegradation.

4.3.5 Short-Term Effectiveness

Alternative 1 would not create new short-term concerns, as no actions are being conducted. The potential health risks to workers in the form of exposure to the solid peroxide in Alternatives 3 and 4 can be controlled through the use of appropriate health and safety measures.

4.3.6 Implementability

Alternative 1 is the easiest alternative to implement, as it requires no action.

Both Alternatives 3 and 4 primarily involve the direct-push injection of an oxidizer; however, Alternative 3 would be slightly easier to implement as it requires fewer injections points than Alternative 4.

4.3.7 Cost

Following is a summary of the estimated costs for the three alternatives. The detailed cost estimates are provided in Tables 3-4 and 3-5.

No.	Remedial Action Alternative	Total Incurred Capital Costs (A)	Total Capital Costs to be Incurred (B)	Total O&M NPV Cost (C)	Total NPV Cost (B+C)
1	No Action	$0	$0	$0	$0
3	Source Removal + Focused Enhanced Aerobic Bioremediation + MNA	$607,000	$165,985	$507,244	$673,229
4	Source Removal + Extended Enhanced Aerobic Bioremediation + MNA	$607,000	$421,164	$512,349	$933,514

Alternative 1 is the least expensive alternative; however, this alternative does not satisfy the effectiveness criterion because it is not expected to achieve the site RAOs within a reasonable timeframe. This alternative is therefore not cost reasonable.

Alternatives 3 and 4 achieve the site RAOs within a reasonable timeframe. However, Alternative 4 costs are approximately $260,285 higher than Alternative 3 due to higher capital costs derived from the larger number of injection points required. Alternative 3 would require a slightly more extensive monitoring program. Alternative 3 requires more years of quarterly monitoring (4 years) compared to Alternative 4's quarterly monitoring requirements (3 years) as the on-site plume will not be as aggressively treated in Alternative 3 and VOC reduction is expected to be achieved between 2 to 4 years; therefore, for cost estimation purposes, it has been assumed that 4 years of quarterly monitoring will be needed for Alternative 3. Due to the expanded provisions for biodegradation, Alternative 4 is expected to reduce VOC concentrations within the first 2 years of implementation; therefore, for cost estimation purposes, it has been assumed that only 3 years of quarterly monitoring will be required.

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With the exception of implementability and cost, Alternative 1 would not effectively comply with any of the criteria outlined above. Therefore, this alternative is dropped from further consideration.

Alternatives 3 and 4 are both expected to comply with the Site's RAOs within a reasonable time frame; both provide protection of human health and environment, comply with the SCGs and provide long-term effectiveness. Once the groundwater is cleaned up the property will be suitable for unrestricted use. Long-term use restrictions or institutional controls (IC) will be required. However, if the property is sold prior to reaching unrestricted use conditions, the ANG will have to agree to place an environmental easement or deed restriction on the property at the time of sale.

The short term impacts of the alternatives are also similar. Both are expected to reduce TMV of site impacted media and Alternative 4 has slightly more implementability concerns than Alternative 3. Alternative 4 is expected to achieve the SCGs in a slightly shorter timeframe. Both alternatives involve application of the same technology, and Alternative 3 requires fewer injection points than Alternative 4 and is less costly. In the short time frame expected for the groundwater to reach standards (2-4 years), the on-site property will continue to be government owned and any groundwater use in the plume area will be precluded via the base master plan.

The cost differential between the two alternatives is $260,285 favorable to Alternative 3. Therefore, given the current knowledge that the plume the plume is dissipating within the boundaries of the GE Property, alternative 3 appears to be the most cost-effective alternative.

Alternative 3 is the recommended remedial alternative because it satisfies the remedy-selection evaluation criteria and addresses the impacted groundwater and soil at the Site in the most cost-effective way. Alternative 3 involves the direct-push injection of solid peroxide in targeted migration pathway areas mostly located within the off-site plume, excavation of the identified source areas, institutional controls and

MNA. The solid peroxide solution in the migration pathways should prevent further off-site migration by completely and permanently destroying dissolved VOCs and enhancing natural bioremediation. Currently impacted on-site groundwater would eventually be treated off-site, and source removal and natural attenuation processes would reduce on-site VOC levels within a reasonable timeframe. Alternative 3 is expected to achieve site RAOs within a relatively short time (i.e., 2 to 4 years).

Implementation of Alternative 3 at the site would involve:

- Use restrictions: Part 5 of the NYSDOH State Sanitary Code will prevent installation of a private potable water supply well in off-site properties affected by the BEX plume as they are served by a public water supply system;
- Indoor Air investigation at the Ramtech Property ;
- Excavation and disposal of the identified source area. Portion already completed in August 2008;
- Enhanced Bioremediation Pilot Study via ISCO. Portion completed in October 2009;
- Installation of approximately 43 peroxide injection points as aerobic biological treatment barriers primarily along Molloy Road and Fairway Drive to control off-site migration of VOCs; Figure 3-1 depicts conceptual design injection locations;
- Quarterly monitoring of BTEX concentrations and natural attenuation parameters in shallow groundwater for 4 years and annually for up to 10 years; and
- Additional injections of solid peroxide at Year 2 at 22 of the original injection locations.

Additional benefits of this alternative include:

- The residual risk remaining after completion of the remedy is expected to be acceptable; thus, human health and the environment would be protected over the long term; and

- Solid peroxide bioremediation is the simplest and most cost-effective technology for the Site's characteristics among the alternatives that utilize active remedial measures.

SECTION 6.0

REFERENCES

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FIGURES

Project No. 0086335.44

Date: 12/03/09

Drawn By: R. Olson

CAD File: G:\\0086335\44\008633544-01.dwg

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Figure 1-1

Site Location Map

174th Fighter Wing

Hancock Air National Guard

Syracuse, New York

ERM 12/09

Project No. 0086335.44

Date: 12/03/09

Drawn By: R. Olson

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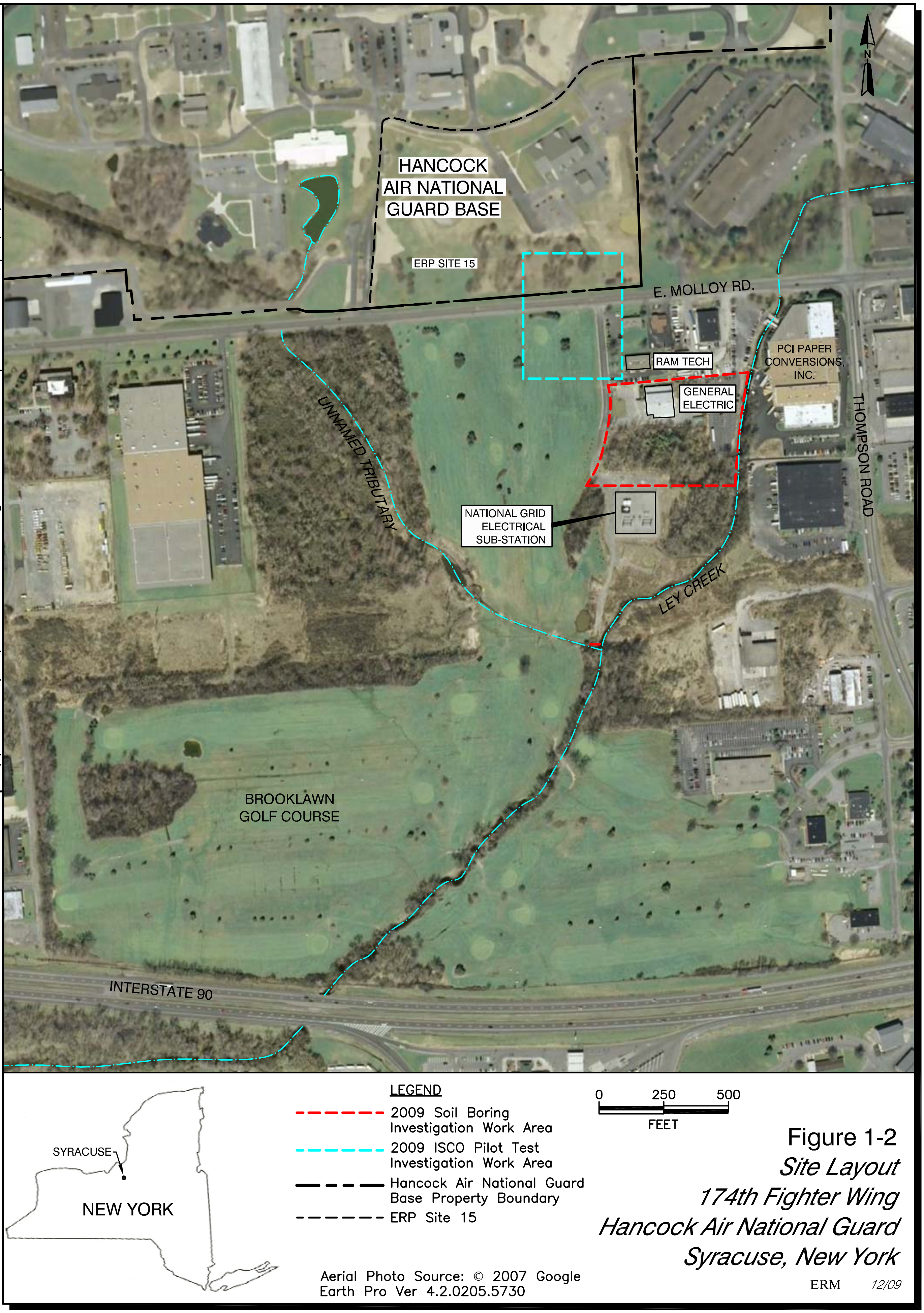

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Figure 1-2

Site Layout

174th Fighter Wing

Hancock Air National Guard

Syracuse, New York

ERM 12/09

Project No. 0086335.44
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Drawn By: R. Olson
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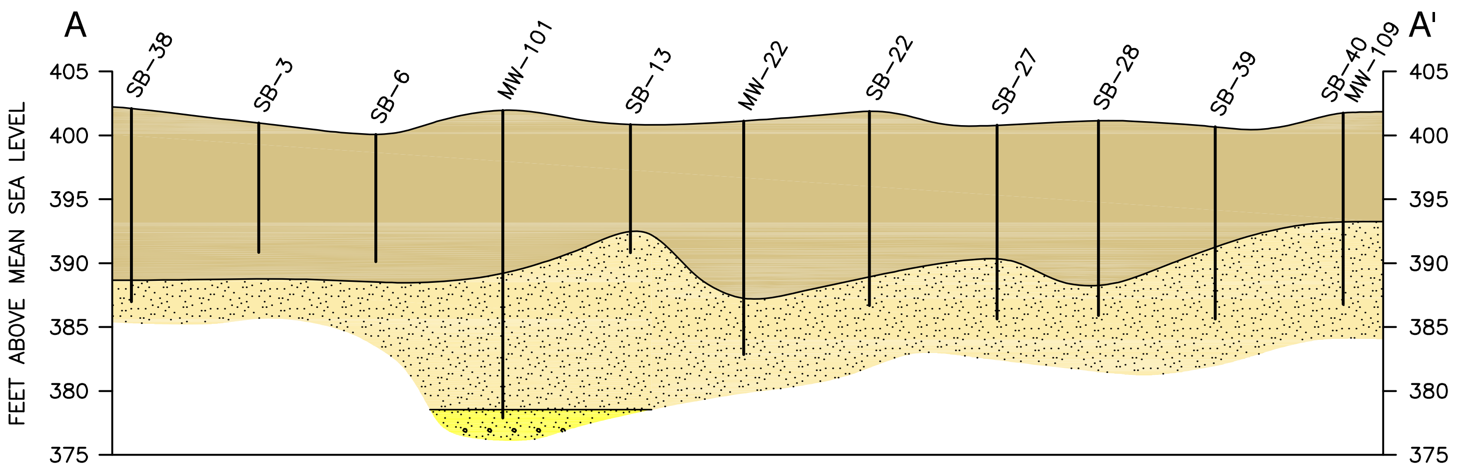
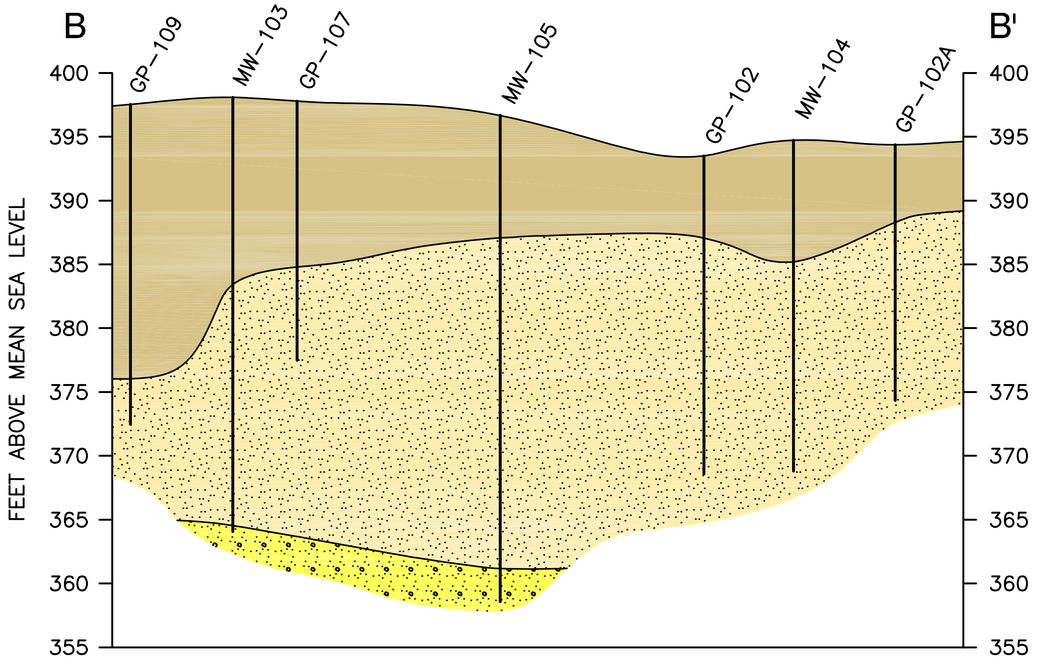
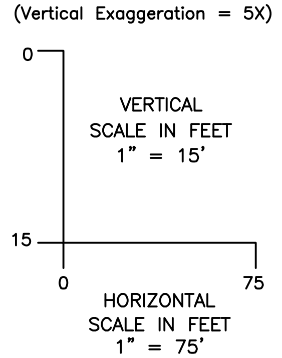
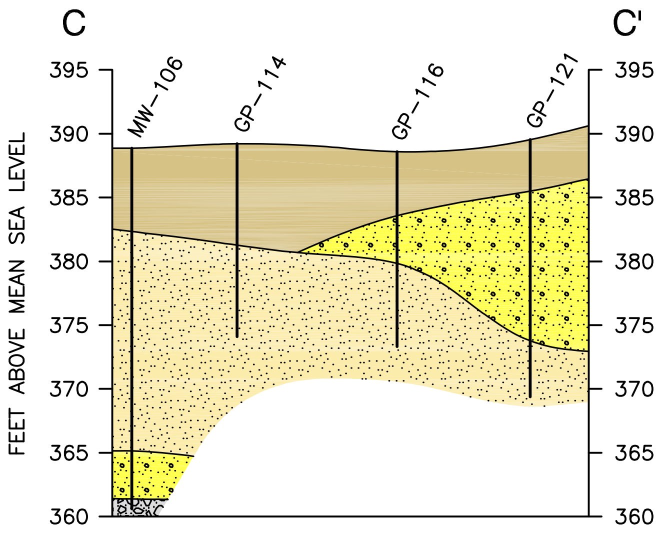


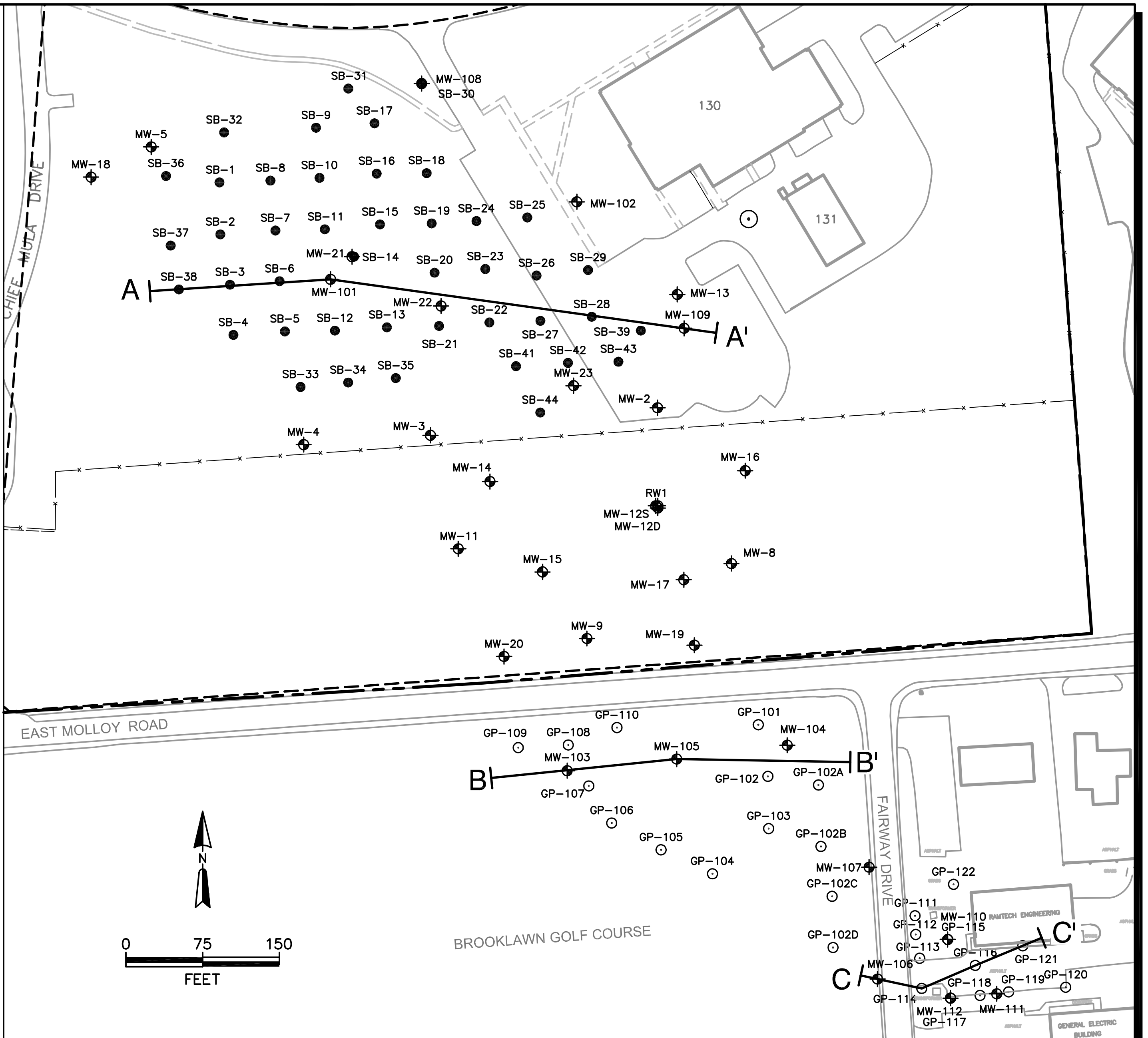






LITHOLOGY KEY

- ▨ Silt Unit
- ▨ Fine Sand and Silt Unit
- ▨ Fine to Medium Grained Sand Unit
- ▨ Glacial Till Unit



CROSS SECTION LOCATION MAP

LEGEND

- ⊕ Monitoring/Recovery Well Location
- ● Soil Boring Location
- ⊙ Direct Push Sample Location
- 131 Building
- —×— Fence
- — — Base Boundary
- - - - ERP Site 15
- A—A' Cross Section Line

Figure 1-3

Cross Sections A-A', B-B', and C-C'
174th Fighter Wing
Hancock Air National Guard
Syracuse, New York

ERM 12/09

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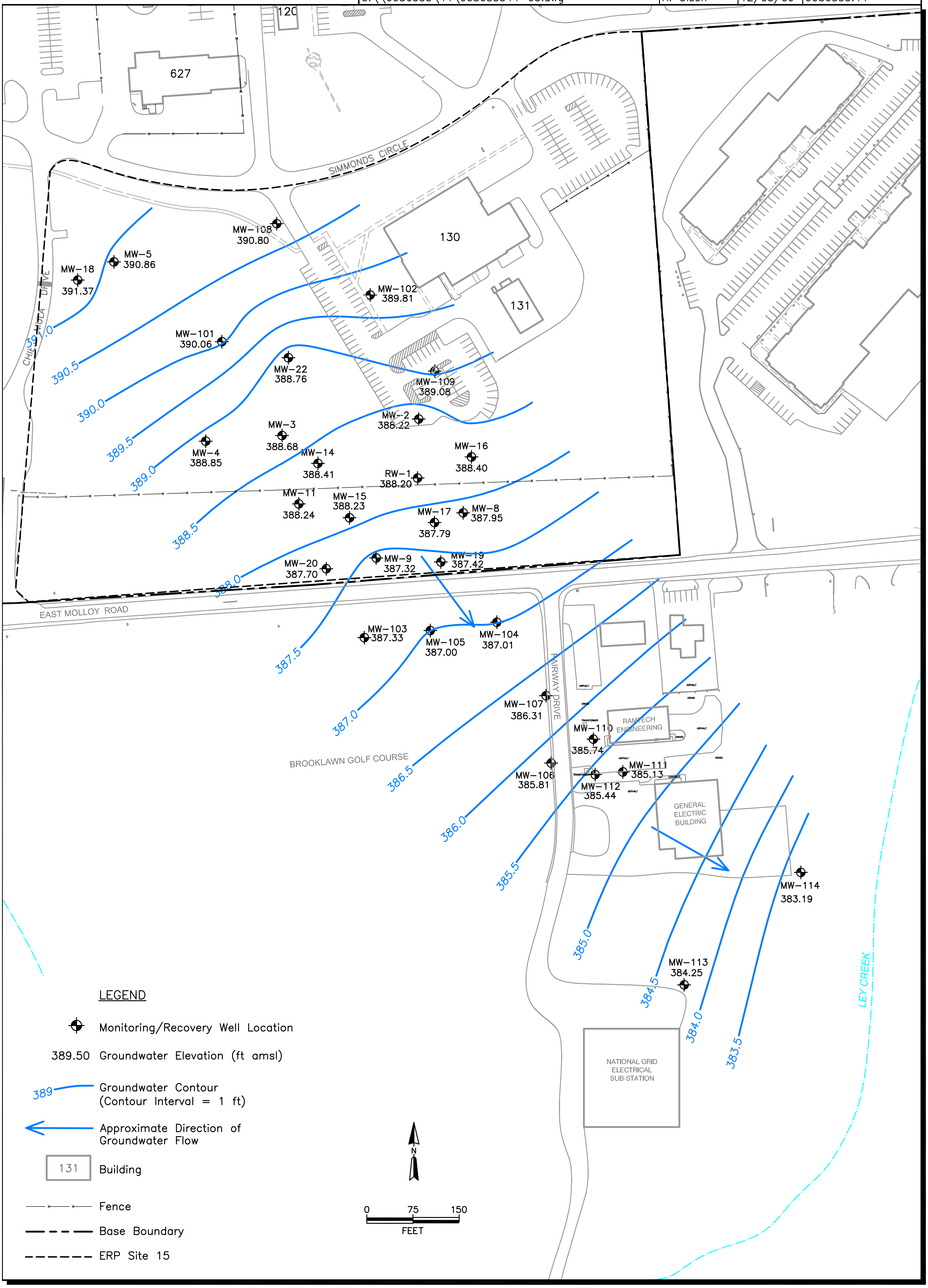

Figure 1-4

Static Groundwater Contour Map

6 October 2009

174th Fighter Wing

Hancock Air National Guard

Syracuse, New York

ERM 12/09

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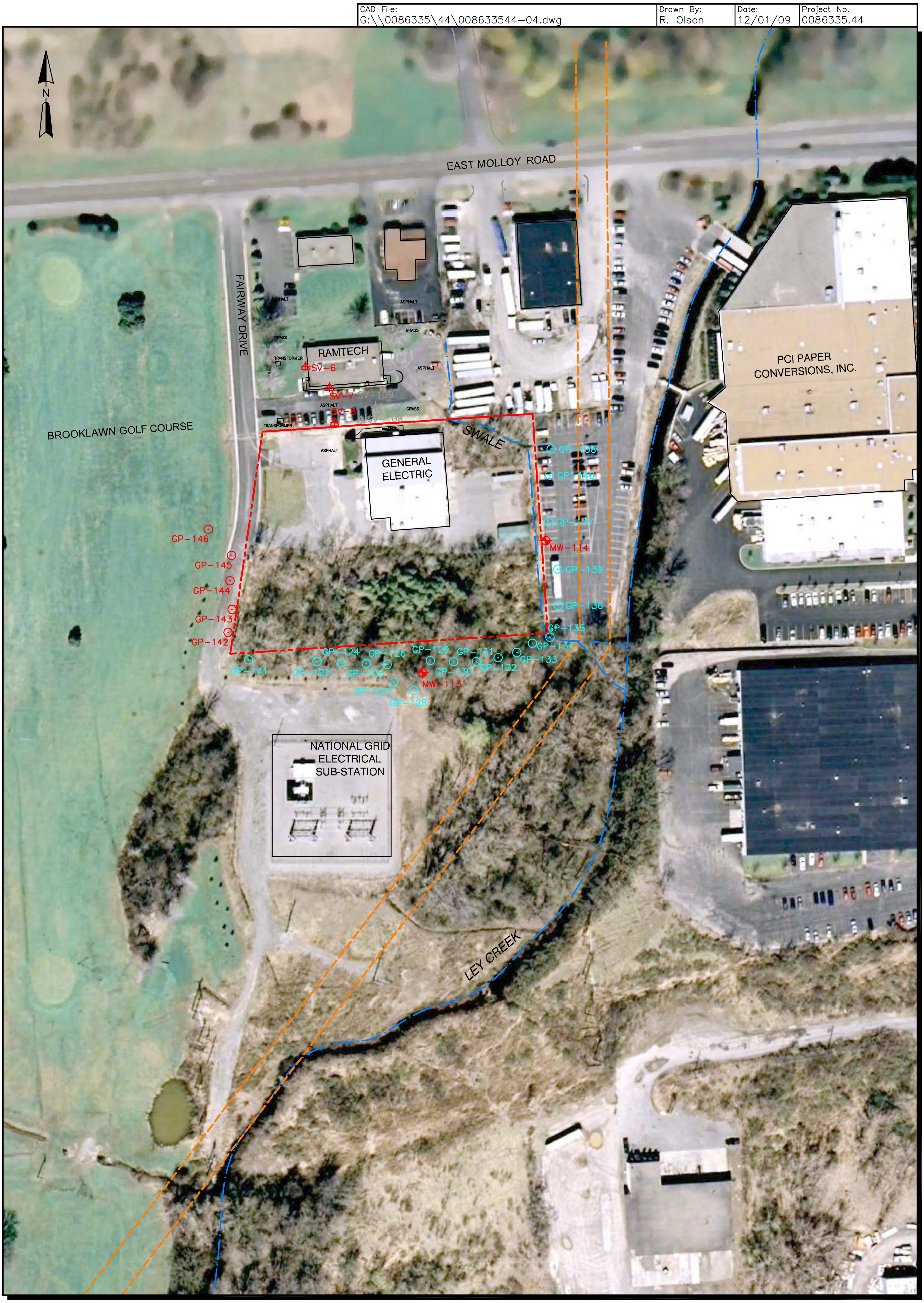

0 60 120
FEET

LEGEND

- ⊙ Boring Location (Spring 2009)
- ⊙ Boring Location (Summer 2009)
- ⊕ Monitoring Well Location (Summer 2009)
- △ Soil Vapor Well Location (Summer 2009)

Aerial Photo Source: © 2009 Google Earth Pro Ver 5.0.11733.9347

- —·— Approximate GE Property Line
- – – – Onondaga County Utility Easement
- —·— Creek/Swale

Figure 1-5

2009 Investigation Boring Locations
174th Fighter Wing
Hancock Air National Guard
Syracuse, New York

ERM 12/09

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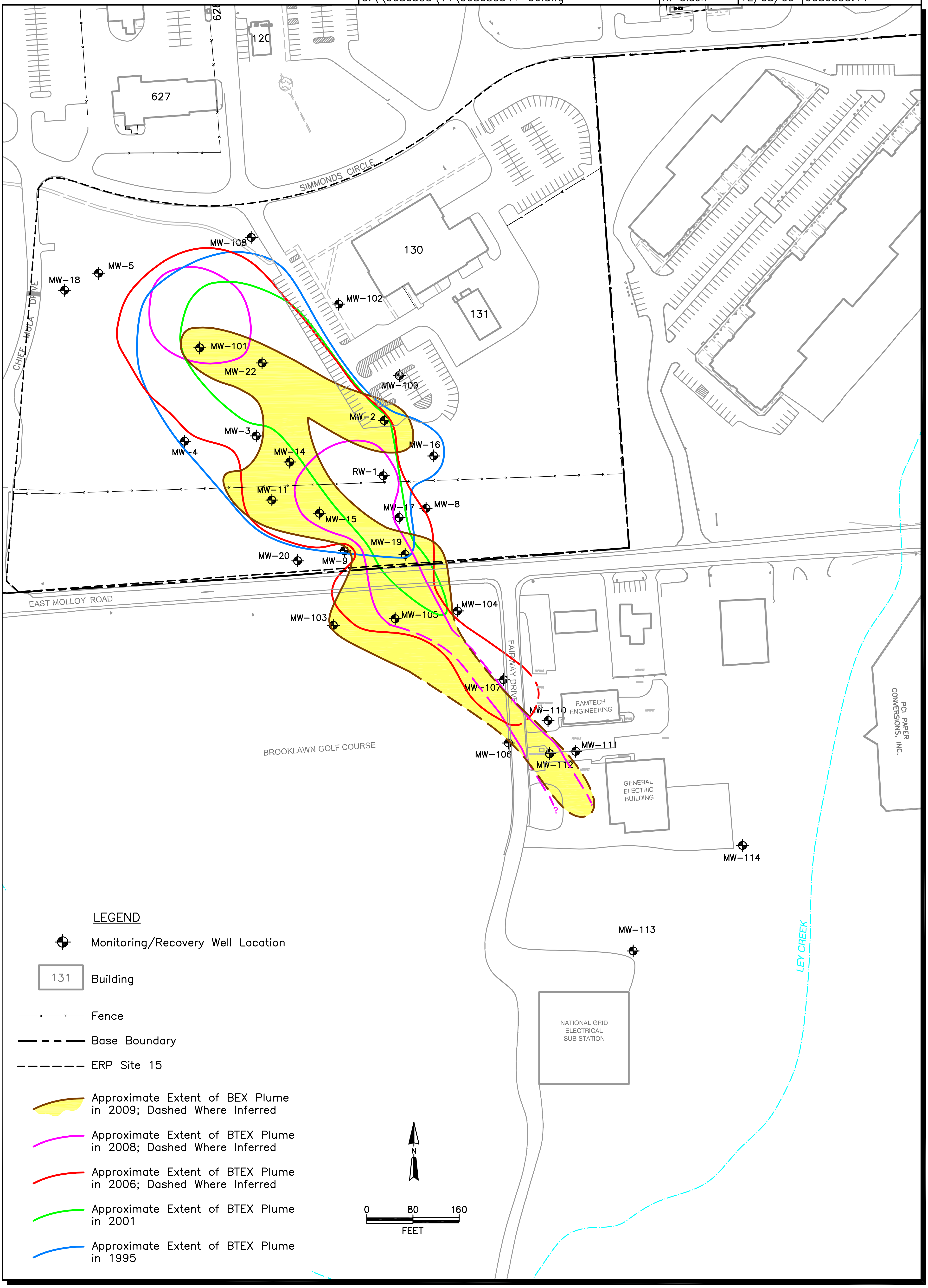

Figure 1-6

Estimated BTEX Extent
1995 to 2009
174th Fighter Wing
Hancock Air National Guard
Syracuse, New York

ERM *12/09*

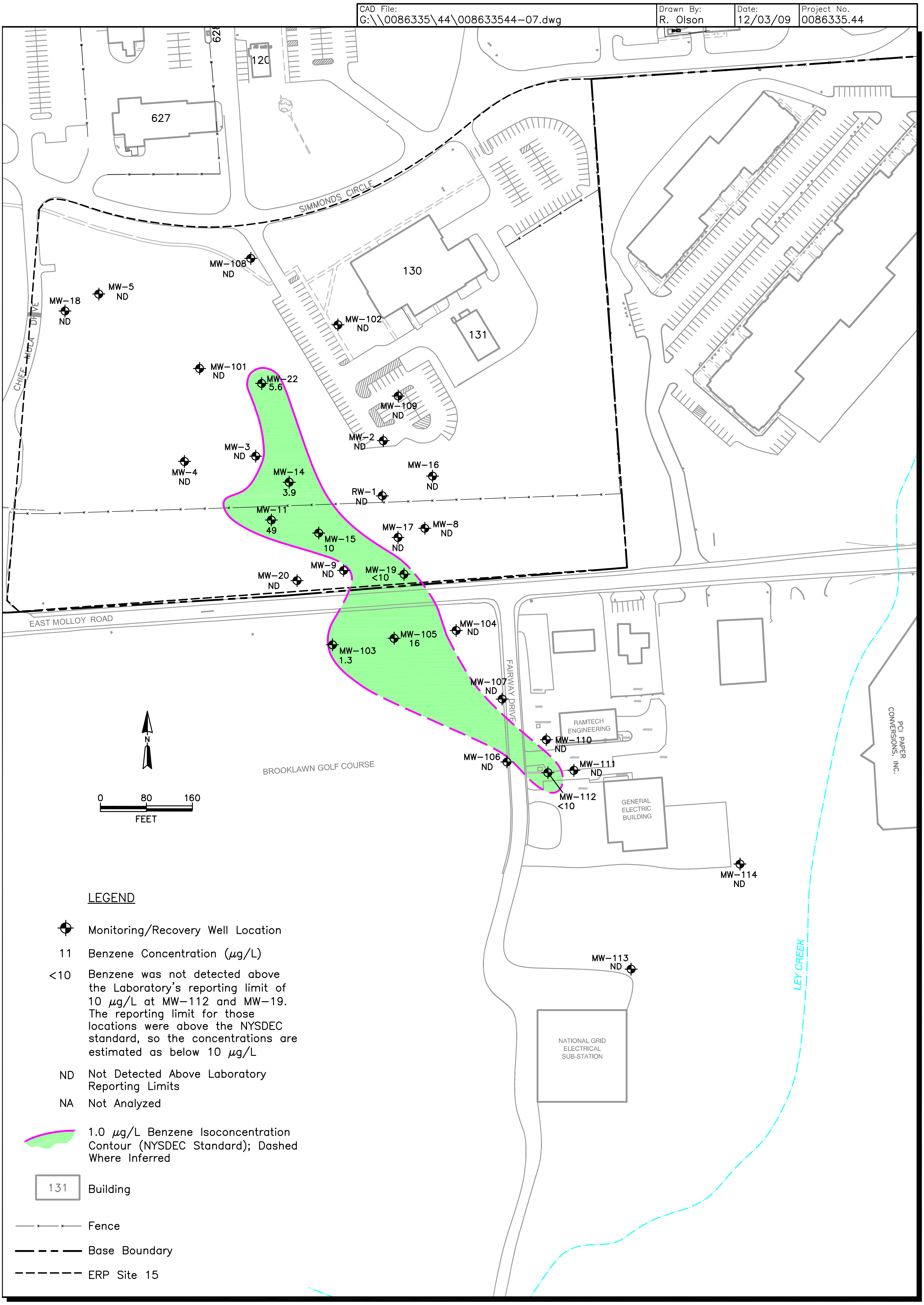

Figure 1-7

Groundwater Isoconcentration Map, Benzene
October 2009
174th Fighter Wing
Hancock Air National Guard
Syracuse, New York

ERM *12/09*

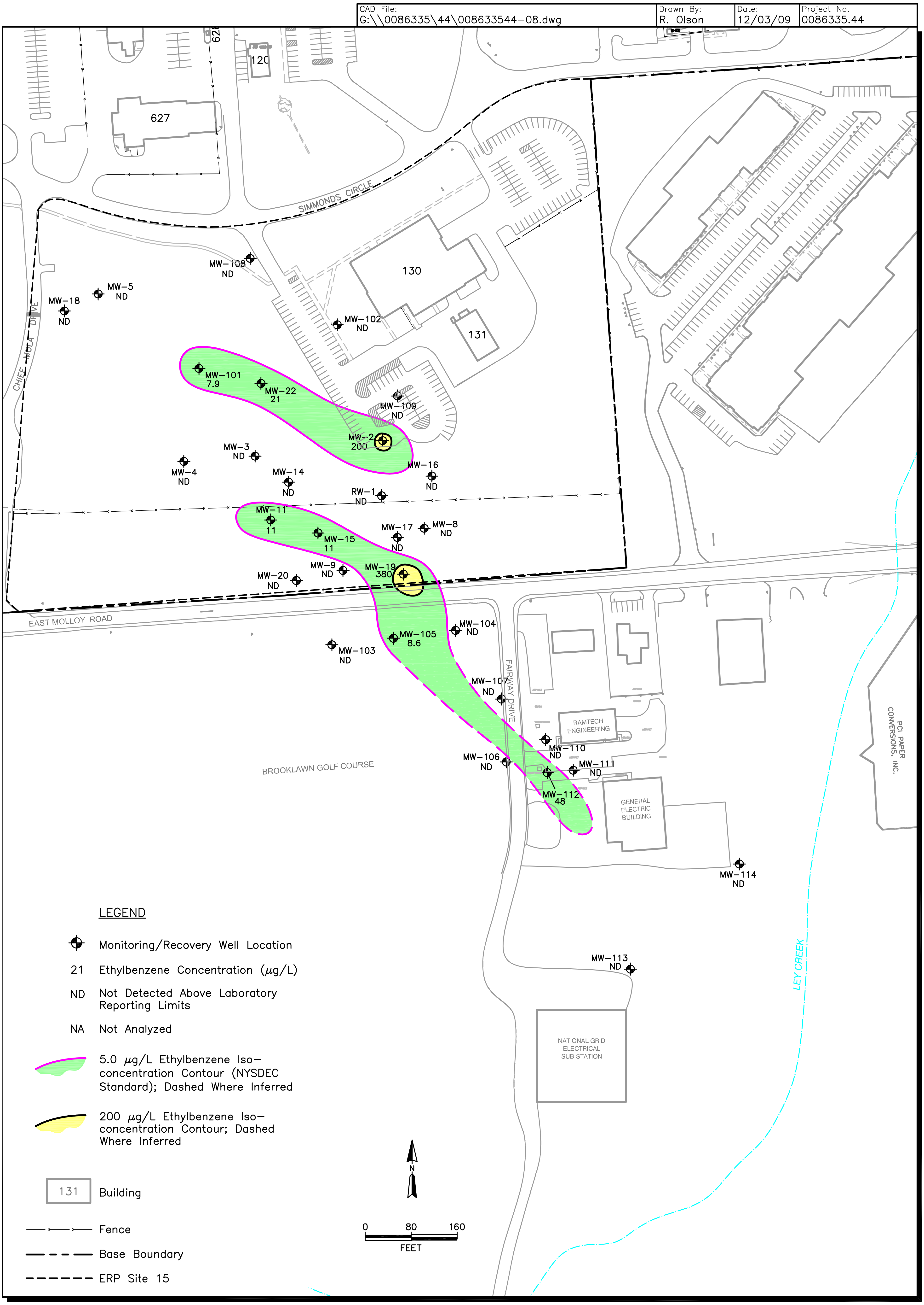

Figure 1-8

Groundwater Isoconcentration Map, Ethylbenzene

October 2009

174th Fighter Wing

Hancock Air National Guard

Syracuse, New York

ERM *12/09*

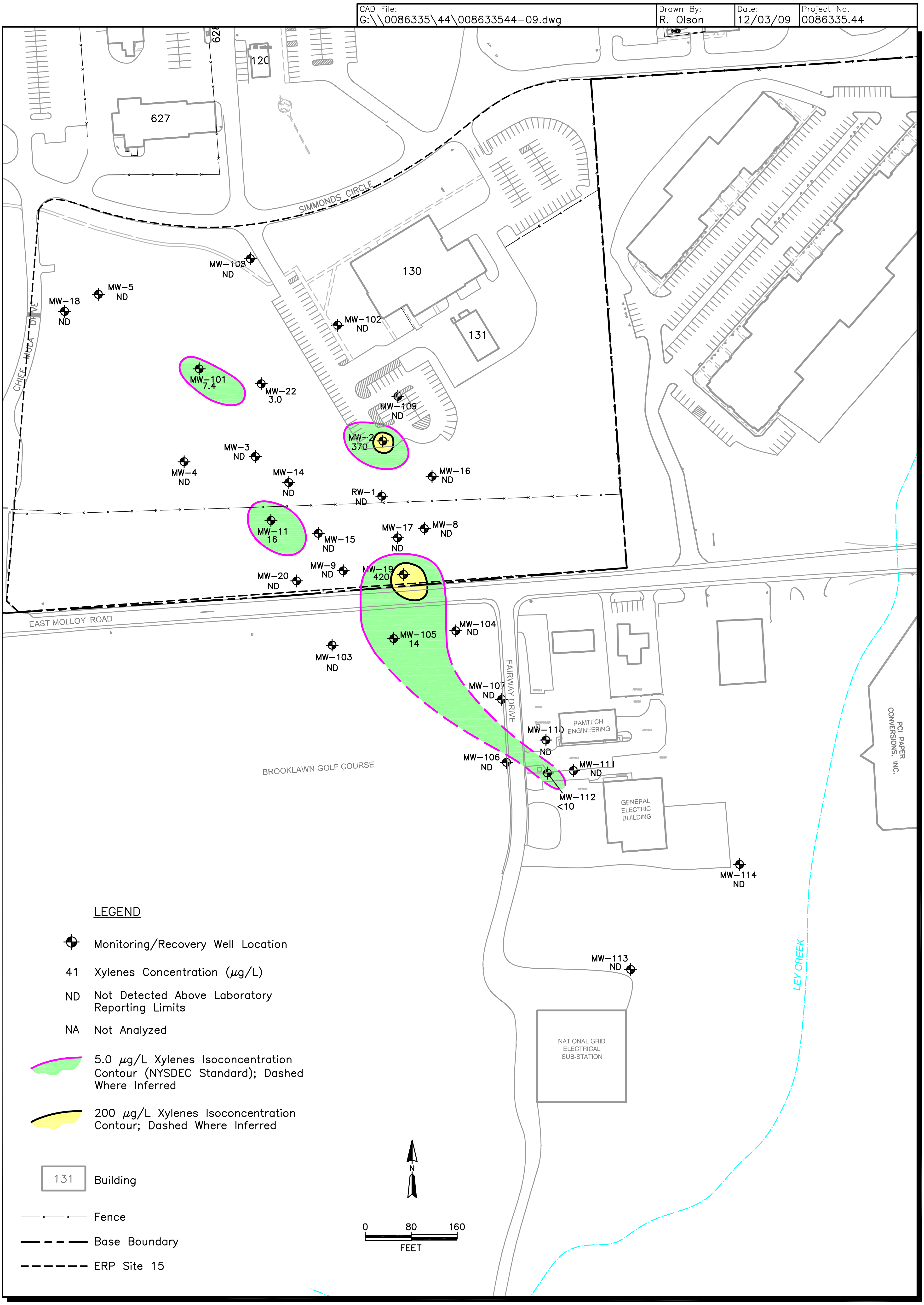

Figure 1-9

Groundwater Isoconcentration Map, Xylenes
October 2009
174th Fighter Wing
Hancock Air National Guard
Syracuse, New York

ERM *12/09*

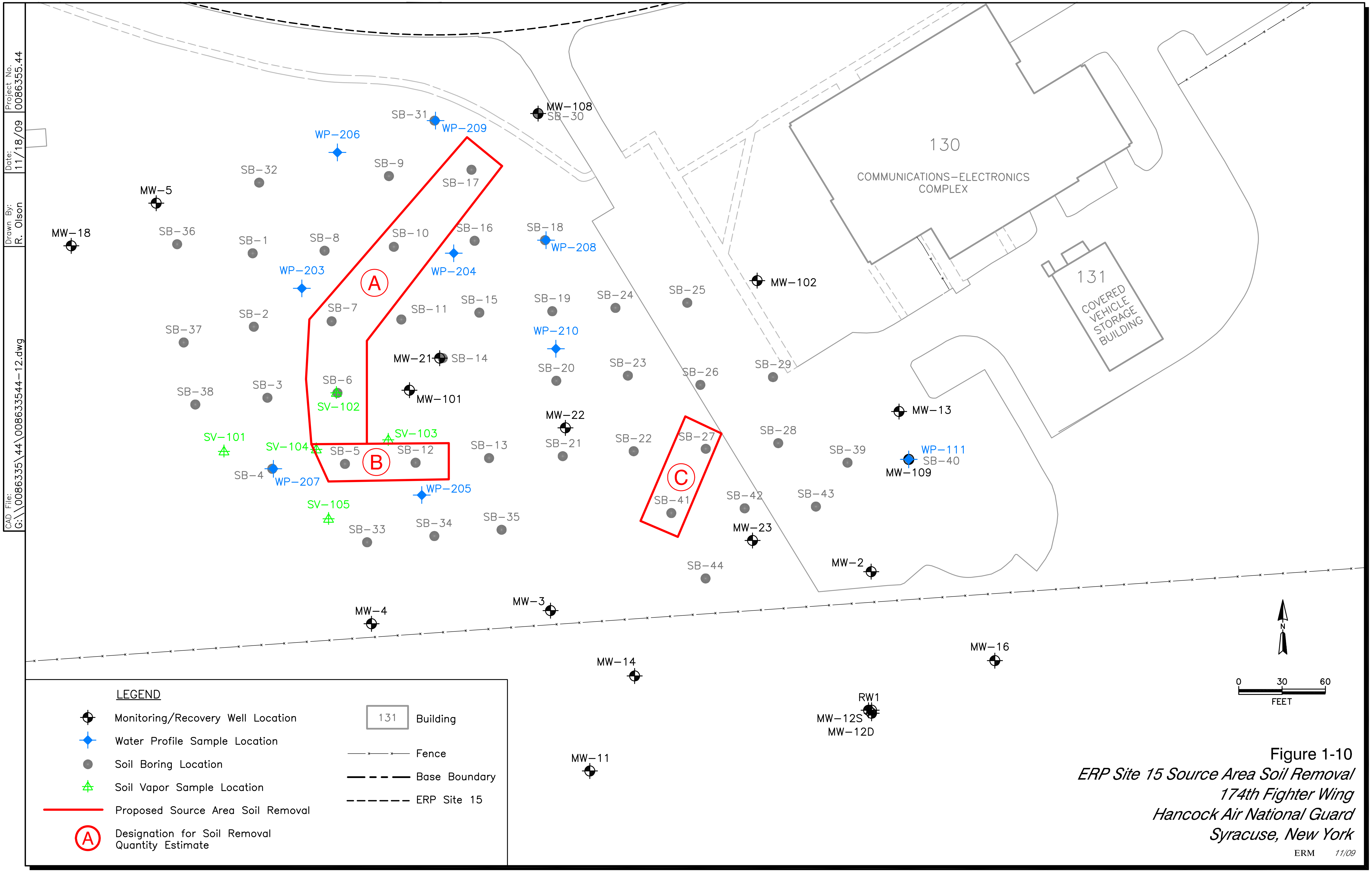

Figure 1-10

ERP Site 15 Source Area Soil Removal
174th Fighter Wing
Hancock Air National Guard
Syracuse, New York

ERM 11/09

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Date: 11/18/09
Project No. 0086355.44

Project No. 0086355.44
Date: 12/03/09
Drawn By: R. Olson
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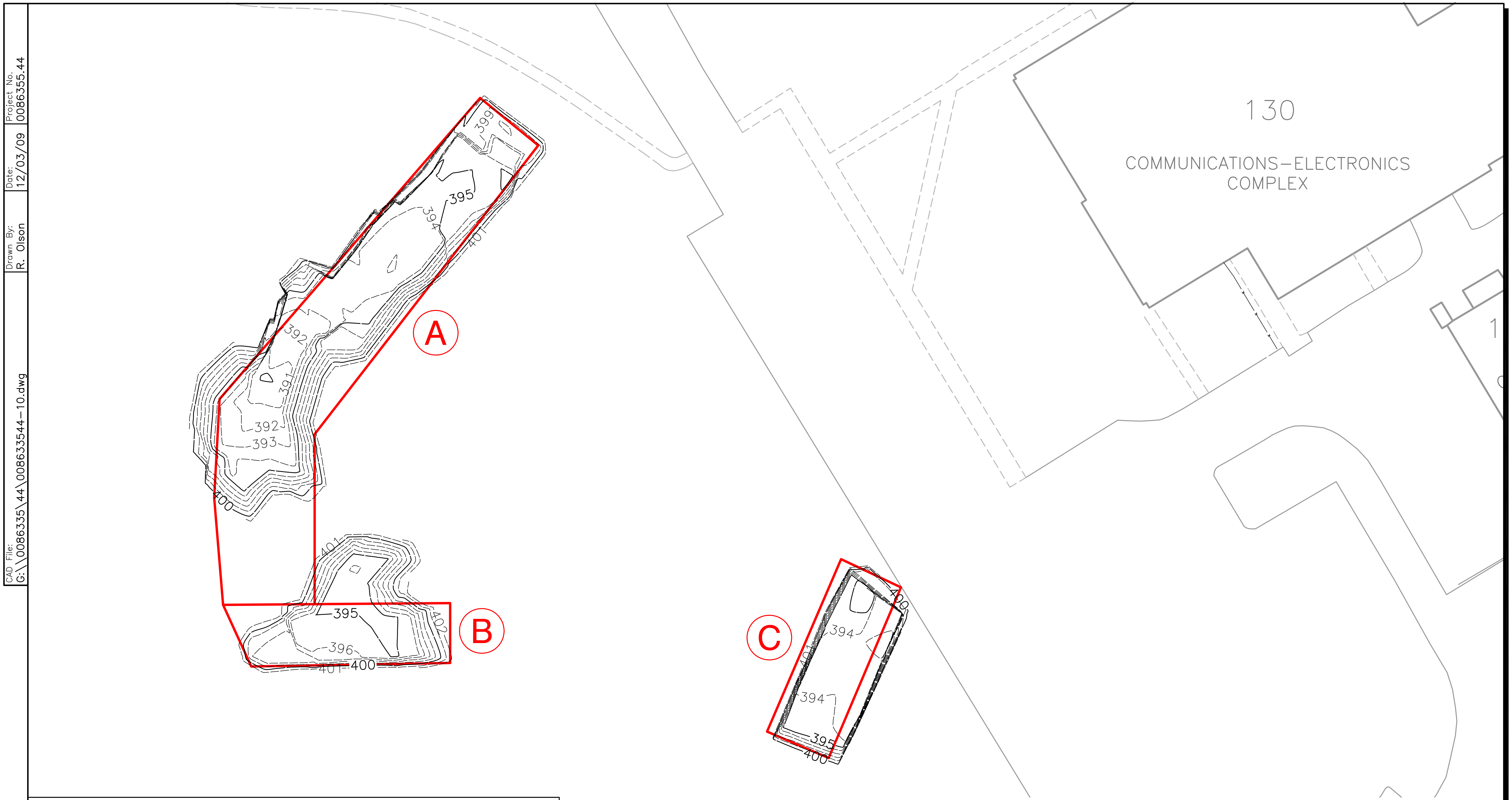

LEGEND

395 Major Excavation Elevation Contours (5 feet)

396 Minor Excavation Elevation Contours (1 foot)

Proposed Source Area Soil Removal

Ⓐ Designation for Soil Removal Quantity Estimate

131 Building

Fence

Base Boundary

ERP Site 15

N

0 20 40
FEET

Figure 1-11

2008 ERP Site 15 Source Area Soil Removal - Excavation Limits

174th Fighter Wing

Hancock Air National Guard

Syracuse, New York

ERM *12/09*

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Drawn By: R. Olson

Date: 12/03/09

Project No. 0086355.44

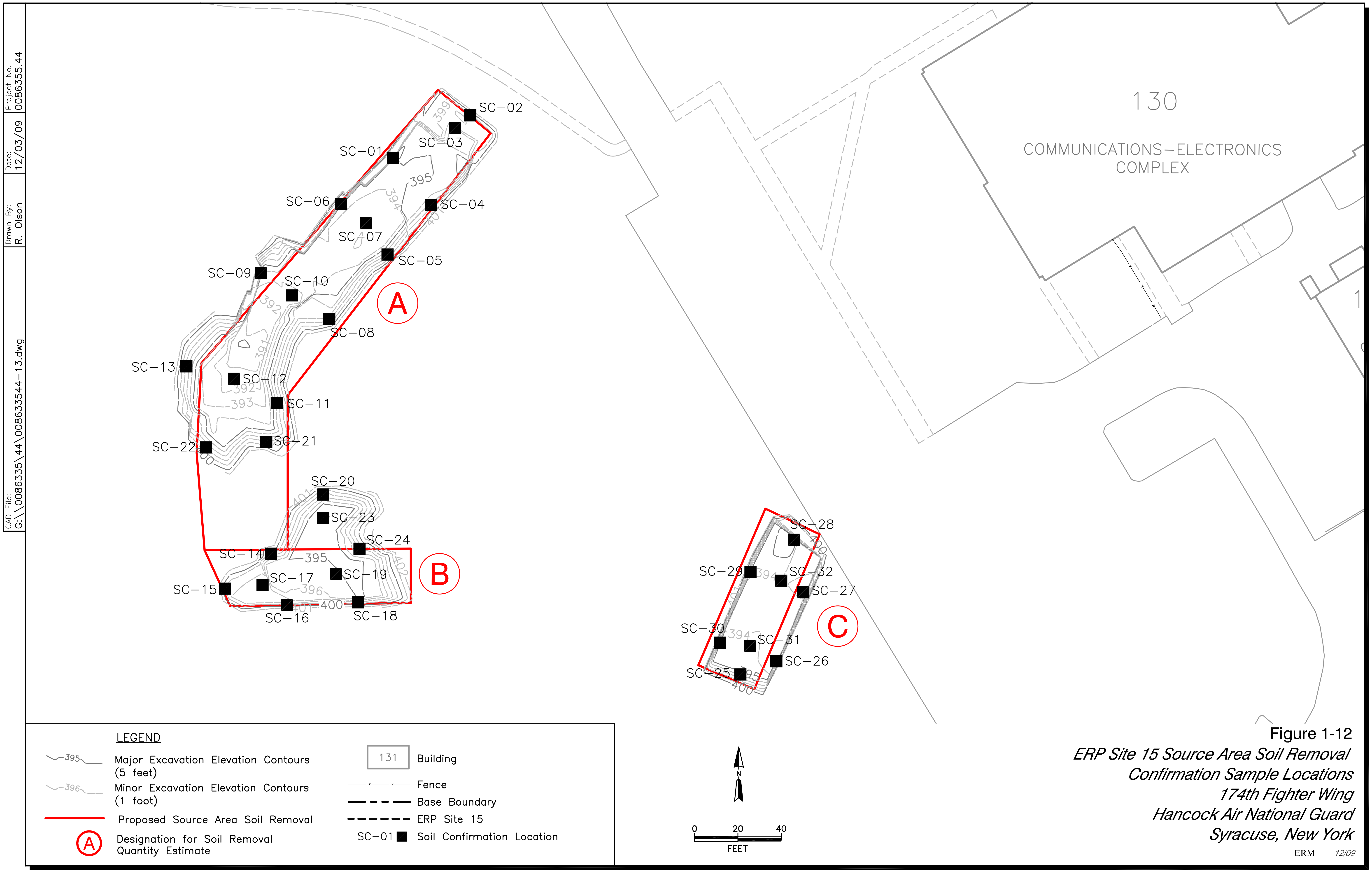

Figure 1-12

ERP Site 15 Source Area Soil Removal
Confirmation Sample Locations
174th Fighter Wing
Hancock Air National Guard
Syracuse, New York

ERM 12/09

CAD File: G:\\0086335\44\008633544-11.dwg	Drawn By: R. Olson	Date: 12/03/09	Project No. 0086335.44

LEGEND

▭ ISCO Pilot Test Areas

● Approximate Injection Location

Aerial Photo Source: © 2007 Google Earth Pro Ver 4.2.0205.5730

—×—×— Fence

— — — Base Boundary

- - - - - ERP Site 15

N

0 30 60
FEET

Figure 1-13

2009 Pilot Test Activity Locations
174th Fighter Wing
Hancock Air National Guard
Syracuse, New York

ERM *11/09*

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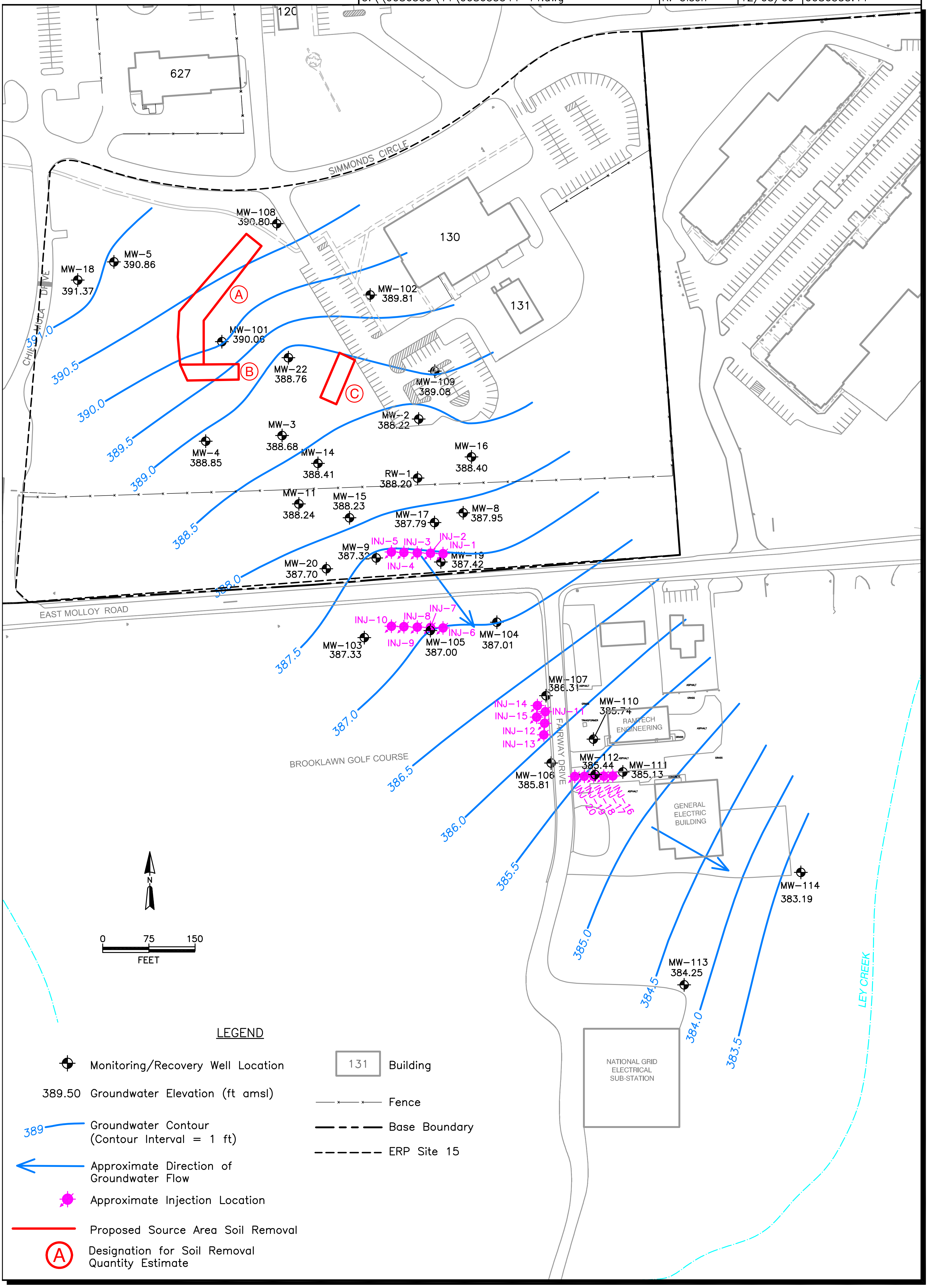

Figure 2-1

Estimated Extent of Impacted Groundater
174th Fighter Wing
Hancock Air National Guard
Syracuse, New York

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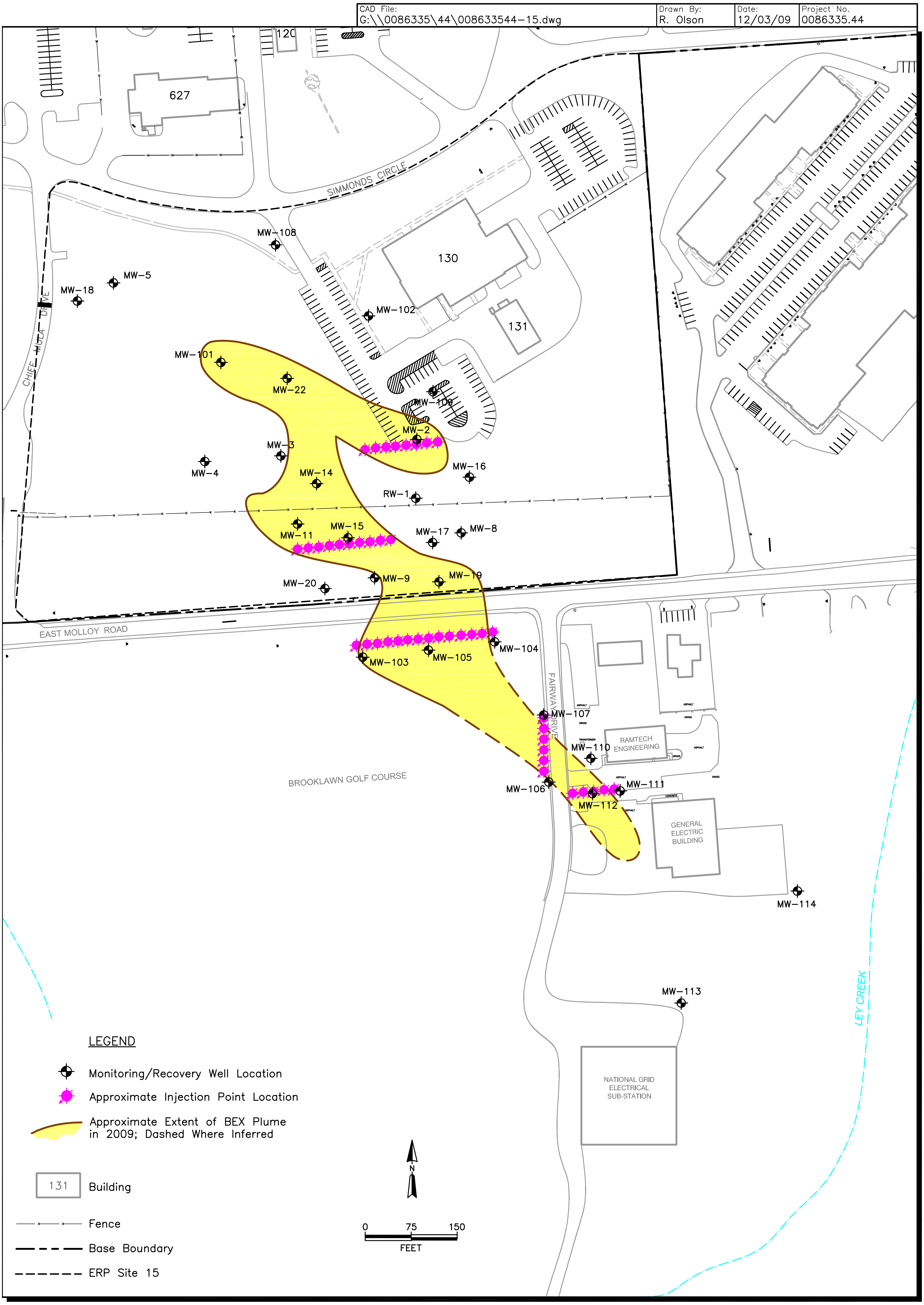

Figure 3-1

Alternative 3: Focused Enhanced ISCO Bioremediation
Proposed Conceptual Design Slurry Injection Locations
174th Fighter Wing
Hancock Air National Guard
Syracuse, New York

ERM *12/09*

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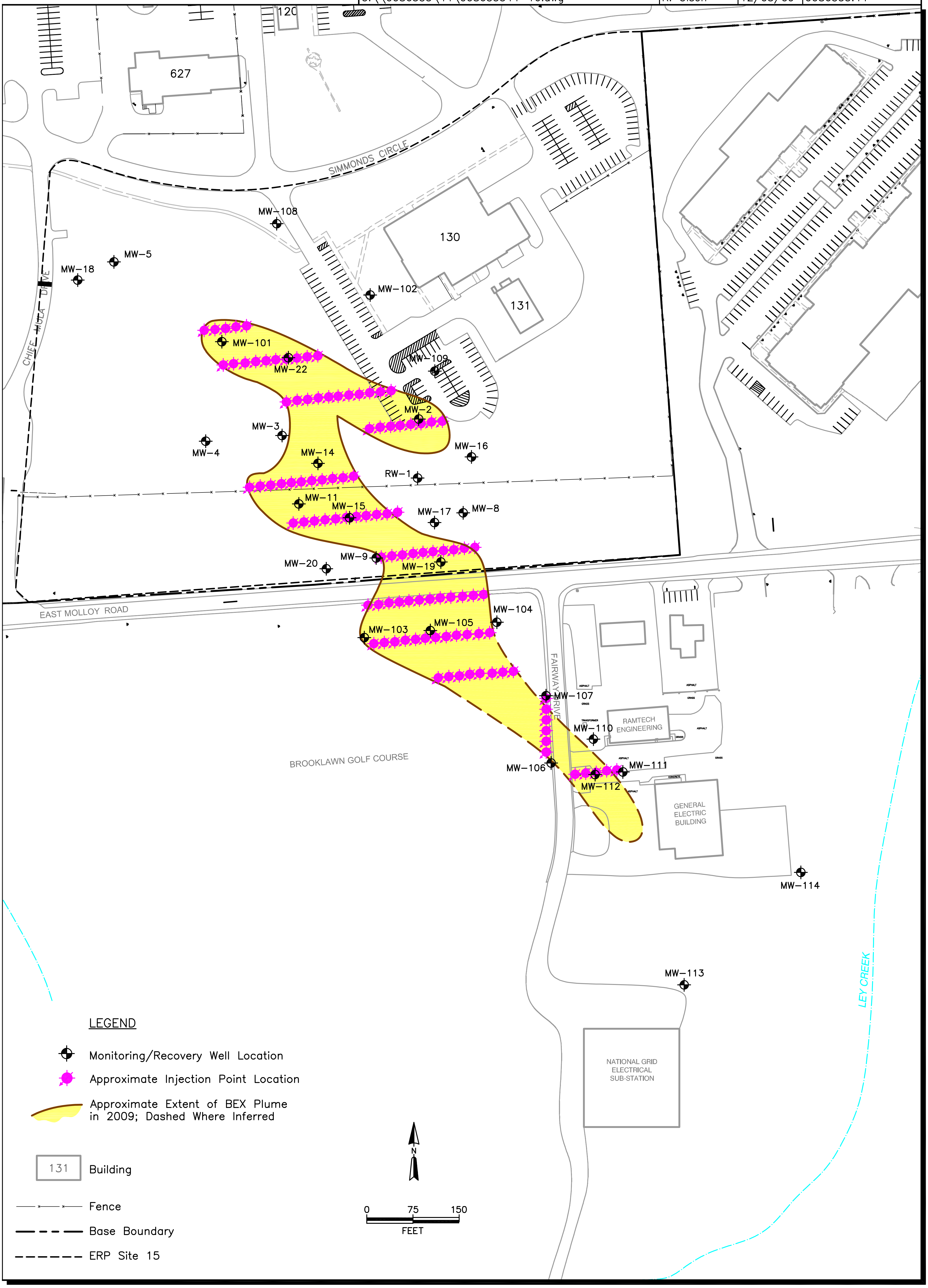

Figure 3-2

Alternative 4: Expanded Enhanced ISCO Bioremediation
Proposed Conceptual Design Slurry Injection Locations
174th Fighter Wing
Hancock Air National Guard
Syracuse, New York

ERM *12/09*

TABLES

TABLE 1-1

Summary of Soil Vapor Data - ERM 2006 Investigation
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

Sample ID	SV-101	SV-102	SV-103	SV-104	SV-105	SV-UPWIND	Indoor 90th Percentile[1]	Outdoor 90th Percentile[1]
VOCs (ug/m^3)								
BENZENE	2.04	---	0.770	---	---	---	15.000	4.300
ETHYL BENZENE	**2.65**	---	0.930	---	---	0.610	7.400	1.100
TOLUENE	---	0.278	**3.82**	1.050	---	**2.12**	12.00	1.40
XYLENE	---	---	2.86	---	---	**2.51**	7.60	1.70
MTBE	---	---	---	---	---	---	27.000	2.100

NOTES:

VOCs = volatile organic compounds determined by USEPA Method TO-15

---- = Below the Reportable Limit

ug/m3- micrograms per cubic meter

SV- Upwind is an ambient air background sample

1- 90% of the analytical results from a NYSDOH study on the concentrations of background VOCs in indoor and outdoor air samples which were collected from homes heated with fuel oil, were below the reported concentration. The New York State does not have standards or guidance for BTEX in soil vapor, to put perspective on the data, the NYSDOH and NYSDEC often compare the soil vapor results to the NYSDOH's background database to determine if there is a potential source or potential risk for vapor intrusion within a building.

- The bolded concentrations exceed the background outdoor air 90th percentile value as noted in the NYSDOH study

FINAL

TABLE 1-2

Summary of Groundwater Data with Applicable Standards - April 2005 through October 2009
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

WELL ID	**MW-2**					**MW-3**					**MW-4**					**MW-5**					**NYSDEC**
Sample Date	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**STANDARD**
VOCs (ug/l)																					
BENZENE	----	----	----	----	----	**200**	**57**	**75**	----	----	----	----	----	----	----	----	----	----	----	----	1
ETHYL BENZENE	3.5	**83**	**52**	----	**200**	**200**	**16**	**61**	----	----	----	----	----	----	----	----	----	----	----	----	5
TOLUENE	----	----	----	----	NA	----	----	0.34J	----	NA	----	----	----	----	NA	----	----	----	----	NA	5
XYLENE	2	**98**	**44**	----	**370**	**95**	**15**	**28**	----	----	----	----	----	----	----	----	----	----	----	----	5
MTBE	----	----	----	----	NA	----	----	----	----	NA	----	----	----	----	NA	----	----	----	----	NA	10
NATURAL ATTENUATION PARAMETERS (mg/l)																					
NITRATE	0.55	----	0.17	0.86	< 0.1	0.21	----	----	0.33	< 0.1	0.13	0.41	----	0.18	0.21	1.20	0.98	0.28	1.3	< 0.1	NA
SULFATE	67.0	7.5	37	98	2.8	2.8	2.4	4	6.0	9.3	26.0	26.0	8.9	3.7	37.0	12.0	15.0	11	8.0	8.6	NA
ALKALINITY	300	310	380	190	400	270	350	300	120	360	190	250	240	40	290	220	260	340	140	280	NA
TOTAL HARDNESS	740	310	350	820	590	380	310	230	57	500	240	250	180	37	350	280	260	270	180	310	NA
AMMONIA	----	0.088	UJ	0.046	0.20	----	0.76	0.065J	----	0.75	----	0.18	----	----	0.11	----	----	UJ	----	<0.03	NA
METHANE	----	8.800	----	0.0076	4.4	0.100	1.600	----	----	0.28	0.011	0.011	----	----	0.012	----	----	----	----	0.02	NA
PARAMETERS MEASURED IN THE FIELD																					
FERROUS IRON	----	3.8	0.9	0.8	4.2	6.1	3.3	2.2	0	2.1	----	1.200	0	0	1	----	0.300	0	0	1.7	NA
pH	7.06	6.95	8.26	6.96	7.54	6.92	6.45	6.77	6.3	6.33	7.30	6.88	8.26	7.16	7.43	7.12	8.21	6.68	7.04	7.14	NA
DISSOLVED OXYGEN	0.00	0.00	0.29	2.28	0.18	0.00	0.00	2.79	7.99	0.12	1.15	0.00	0	0.64	0.49	4.80	0.00	0.77	7.70	0.00	NA
OXIDATION REDUCTION POTENTIAL	76	-127	-76	123.9	44.4	-61	-81	-8	146.6	-71	43	-113	-46	186.9	44	146	-50	121	41.6	-109	NA
CONDUCTIVITY	1.120	0.999	1.4	6.794	1.471	0.531	0.811	0.76	0.106	0.822	0.366	0.803	0.391	0.067	0.440	0.391	0.362	0.577	0.377	0.595	NA
FIELD OBSERVATIONS	----	----	----	----	---	Odor	Odor	Odor	----	---	----	----	----	----	---	----	----	----	----	---	----

NOTES:

ug/L = Micrograms per liter

VOCs - volatile organic compounds determined by USEPA Method 8260

NYSDEC Standards - NYS Division of Water Technical and Operational Guidance Series (1.1.1) 1998

The MTBE ground water standard is from NYSDEC's TAGM 8086

- Bold concentrations exceedance of the NYSDEC Standards or Guidance Value

J = Results greater than the reporting limit that are considered estimated.

UJ= Results less than the reporting limit that are considered estimated.

---- = the compound was not detected at a concentration above the laboratory reporting limit

<10 J- compound were not detected above the laboratory's reporting limit of 10 ug/L. The laboratory's reporting limit exceeds NYSDEC Standard for the compound so the concentration are estimated as below 10ug/l.

Natural Attenuation Parameters are used to characterize the physical, chemical and biological response of a hydrologic system to contamination.

Dissolved Oxygen, Oxidation Reduction Potential, pH and conductivity were measured in the field using a Horiba U-22 and flow through cell just prior to collecting samples.

Ferrous Iron concentration were measured using a HACH Test Kit

Ferrous Iron and DO are reported in mg/L

pH is reported in standard units

Oxidation Reduction Potential is reported in mV

Conductivity is reported in ms/cm

Odor = "Petroleum-like" odor

mg/L= Milligrams per liter

Sheen= Sheen on purge water and/or sample

A Enhanced Bioremediation Pilot Test was conducted in May 2009

FINAL

TABLE 1-2

Summary of Groundwater Data with Applicable Standards - April 2005 through October 2009
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

WELL ID	**MW-8**					**MW-9**					**MW-11**					**MW-14**					**NYSDEC**
Sample Date	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**STANDARDS**
VOCs (ug/l)																					
BENZENE	----	----	----	----	----	----	----	----	----	----	**32**	**31**	**17**	----	**49**	**3.7**	**4.5**	**2**	----	**3.9**	1
ETHYL BENZENE	**6.4**	----	----	----	----	----	----	----	----	----	----	1.4	0.63J	----	**11**	----	1.2	0.22J	----	----	5
TOLUENE	----	----	----	----	NA	----	----	----	----	NA	----	----	0.11J	----	NA	----	----	----	----	NA	5
XYLENE	4	----	----	----	----	----	----	----	----	----	----	**5.2**	0.36J	----	16	----	----	----	----	----	5
MTBE	----	----	----	----	NA	----	----	----	----	NA	----	2.2	----	----	NA	----	1.9	----	----	NA	10
NATURAL ATTENUATION PARAMETERS (mg/l)																					
NITRATE	0.20	----	----	1.2	< 0.1	0.16	0.37	0.1	0.91	< 0.1	0.23	0.15	----	0.34	<0.1	0.77	----	----	0.26	<0.1	NA
SULFATE	24.0	28.0	42	8.7	52.0	38.0	21.0	20	6.1	12.0	8.8	22.0	22	72	4.5	24.0	43.0	45	66.0	45.0	NA
ALKALINITY	320	320	250	88	400	110	200	270	32	260	330	330	260	370	360	230	320	370	350	340	NA
TOTAL HARDNESS	380	120	370	96	650	130	360	83	26	220	320	320	370	440	510	230	350	380	400	470	NA
AMMONIA	----	----	UJ	----	< 0.03	----	0.25	0.12J	0.14	0.37	----	----	0.042J	----	<0.03	----	----	0.2	----	<0.03	NA
METHANE	0.730	0.015	----	0.0024	0.011	----	0.020	----	----	----	0.006	0.740	----	0.052	1.6	1.800	0.130	0.039	0.14	0.16	NA
PARAMETERS MEASURED IN THE FIELD																					
FERROUS IRON	2.0	2.4	1	0.8	1.2	0.1	2.0	1.05	1.1	2.0	4.0	4.4	1.6	2.5	2.2	0.5	2.8	NM	1.4	2.0	NA
pH	6.94	7.12	4.58	6.29	7.70	6.27	6.51	6.41	6.64	8.31	7.38	7.19	4.51	7.29	7.00	6.96	7.07	7.33	7.13	7.68	NA
DISSOLVED OXYGEN	0.00	0.00	10.9	6.21	0.35	0.00	0.00	0	10.09	3.02	0.00	0.00	11.36	0.23	0.00	2.12	0.00	0	0.20	0.15	NA
OXIDATION REDUCTION POTENTIAL	-28	-126	271	41	12.8	152	-26	0.43	109.9	-144.7	-271	-155	270	-93.1	-163	-14	-137	-121	-50.2	14.7	NA
CONDUCTIVITY	0.706	0.999	0	0.172	0.873	1.270	0.969	0.83	0.137	1.006	0.643	0.97	0	1.056	1.280	0.496	0.9	0.91	0.567	0.467	NA
FIELD OBSERVATIONS	----	----	----	----	----	Odor	Odor	----	----	----	Odor	Odor	----	----	Odor	Odor	Odor	Odor	Dye Visible	Dye Visible	----

NOTES:

ug/L = Micrograms per liter

VOCs - volatile organic compounds determined by USEPA Method 8260

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Ferrous Iron concentration were measured using a HACH Test Kit

Ferrous Iron and DO are reported in mg/L

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TABLE 1-2

Summary of Groundwater Data with Applicable Standards - April 2005 through October 2009
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

WELL ID	**MW-15**					**MW-16**					**MW-17**					**MW-18**					**NYSDEC**
Sample Date	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**STANDARDS**
VOCs (ug/l)																					
BENZENE	**100**	**140**	**66**	**6.8**	**10**	----	----	----	----	----	----	----	0.18J	----	----	----	----	----	----	----	1
ETHYL BENZENE	**28**	**33**	**38**	----	**11**	----	----	0.25J	----	----	----	2	**49**	----	----	----	----	----	----	----	5
TOLUENE	----	----	----	----	NA	----	----	0.38J	----	NA	----	----	----	----	NA	----	----	----	----	NA	5
XYLENE	3	----	----	----	----	----	----	----	----	----	----	----	**31**	----	----	----	----	----	----	----	5
MTBE	----	2.8	----	----	NA	----	----	----	----	NA	----	----	----	----	NA	----	----	----	----	NA	10
NATURAL ATTENUATION PARAMETERS (mg/l)																					
NITRATE	0.21	----	----	0.8	<0.1	0.20	----	0.11	0.48	<0.1	3.20	0.13	----	3.3	<0.1	1.40	0.34	0.83	0.52	<0.1	NA
SULFATE	37.0	17.0	27	28	31	62.0	37.0	99	63	63	58.0	16.0	41	27	19	13.0	12.0	13	6.0	14.0	NA
ALKALINITY	380	340	290	410	340	260	350	520	400	370	260.0	360.0	320	260	370	290	310	320	92	390	NA
TOTAL HARDNESS	430	370	380	460	420	450	390	480	530	550	300	370	370	260	540	300	280	300	99	430	NA
AMMONIA	----	----	0.11J	0.041	<0.03	----	----	5.1J	----	<0.03	1.50	1.20	0.13J	----	0.22	----	----	UJ	----	<0.03	NA
METHANE	2.100	1.400	----	0.93	0.19	----	0.057	0.0078	----	0.0089	0.033	1.400	----	----	1.1	----	----	----	----	0.0029	NA
PARAMETERS MEASURED IN THE FIELD																					
FERROUS IRON	4.6	3.1	2.95	2.2	2.4	----	0.400	NM	0.2	0.2	----	2.200	3.2	0	1.4	----	0.000	0	0	0	NA
pH	7.00	6.88	7.2	7.16	7.55	7.17	6.99	7.15	6.67	7.60	7.35	6.83	7.01	6.75	6.69	7.25	8.10	7.13	7.07	7.49	NA
DISSOLVED OXYGEN	0.00	0.00	0	0.31	0.13	1.70	0.00	0	1.30	0.42	0.00	0.00	0	6.29	0.00	0.20	0.00	0	1.06	1.11	NA
OXIDATION REDUCTION POTENTIAL	-67	150	-153	-99.1	7.8	-85	-16	-19	153.8	18.9	-308	-139	-98	53.9	-115	-202	127	185	181.1	44.5	NA
CONDUCTIVITY	1.170	1.01	0.99	0.630	525	1.050	0.97	3.06	1.052	0.891	0.623	0.6	0.9	0.522	1.260	0.486	0.378	0.986	0.143	0.568	NA
FIELD OBSERVATIONS	----	----	Odor	----	Odor	----	----	----	Dye Visible	Dye Visible	----	----	----	----	----	----	----	----	----	----	----

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Odor = "Petroleum-like" odor
mg/L= Milligrams per liter
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A Enhanced Bioremediation Pilot Test was conducted in May 2009

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TABLE 1-2

Summary of Groundwater Data with Applicable Standards - April 2005 through October 2009

174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

WELL ID	MW-19							MW-20					MW-22					NYSDEC
Sample Date	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**STANDARDS**
VOCs (ug/l)																		
BENZENE	**28**	**33**	**17J**	----	0.71 J	**6**	**< 10**	----	----	----	----	----	**110**	**70**	**51**	----	**5.6**	1
ETHYL BENZENE	**300**	**610**	**270**	**8.5**	**17**	**410**	**380**	----	----	----	----	----	**89**	**32**	**82**	----	**21**	5
TOLUENE	----	----	----	----	NA	NA	NA	----	----	----	----	NA	----	----	0.34J	----	NA	5
XYLENE	**650**	**860**	**460**	**9**	**20**	**760**	**420**	----	----	----	----	----	**88**	**46**	**90**	----	3	5
MTBE	----	----	----	----	NA	NA	NA	----	----	----	----	NA	----	----	----	----	NA	10
NATURAL ATTENUATION PARAMETERS (mg/l)																		
NITRATE	0.19	----	----	0.28	----	----	<0.1	0.45	----	----	1.4	<0.1	1.50	----	0.3	1.9	<0.1	NA
SULFATE	15.0	----	11	25.0	20.0	6.7	4.9	36.0	15.0	240	11.0	9.4	32.0	8.8	41	16.0	31.0	NA
ALKALINITY	350	330	240	410	330	330	340	340	340	370	67	350	330	400	370	170	410	NA
TOTAL HARDNESS	340	350	330	350	400	560	550	420	330	300	83	330	390	340	340	160	570	NA
AMMONIA	----	----	0.75J	----	----	0.077	0.16	----	----	0.03J	----	< 0.03	----	0.12	0.1	----	<0.03	NA
METHANE	3.400	3.500	----	0.99	0.61	0.98	3	0.018	0.027	----	----	0.13	2.300	1.800	1.3	0.017	1.0	NA
PARAMETERS MEASURED IN THE FIELD																		
FERROUS IRON	----	4.100	2.2	2	1.7	2.7	1.9	----	2.500	1.2	0	1.8	----	5.300	NM	0	0.8	NA
pH	6.78	6.68	4.66	6.37	7.1	6.64	8.21	7.06	6.71	4.69	6.47	7.48	6.87	7.81	5.19	6.57	6.85	NA
DISSOLVED OXYGEN	0.00	0.00	10.95	0.88	0.71	0.29	0.21	0.00	0.00	11.17	0.26	0.23	5.70	0.00	9.55	0.16	0.00	NA
OXIDATION REDUCTION POTENTIAL	-79	-101	267	23.7	11.6	-33.4	-132.6	-390	-76	261	207.5	-50.1	-242	-92	226	174.9	-25	NA
CONDUCTIVITY	1.210	0.91	0	1.260	0.997	1.052	1.450	0.839	0.954	0	0.143	0.807	0.607	1.07	0	0.155	1.410	NA
FIELD OBSERVATIONS	----	----	----	----	----	Odor	----	----	----	----	----	----	Odor	Odor	----	Odor	----	----

NOTES:

ug/L = Micrograms per liter

VOCs - volatile organic compounds determined by USEPA Method 8260

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TABLE 1-2

Summary of Groundwater Data with Applicable Standards - April 2005 through October 2009
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

WELL ID	RW-1					MW-101			MW-102			MW-103			MW-104			NYSDEC
Sample Date	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Nov-06**	**Feb-08**	**##**	**Nov-06**	**Feb-08**	**Oct-09**	**Nov-06**	**Feb-08**	**Oct-09**	**Nov-06**	**Feb-08**	**##**	**STANDARDS**
VOCs (ug/l)																		
BENZENE	----	**2.4**	**1.4J**	----	----	**8.9**	----	----	----	----	----	----	----	**1.3**	----	----	----	1
ETHYL BENZENE	**11.0**	**18**	**60**	**45**	----	**110**	**22**	**7.9**	----	----	----	----	----	----	----	----	----	5
TOLUENE	----	----	0.4J	----	NA	----	----	NA	----	----	NA	----	----	NA	----	----	NA	5
XYLENE	**21.0**	**36.0**	**30**	**60**	----	**230**	**41**	**7.4**	----	----	----	----	----	----	----	----	----	5
MTBE	----	----	----	----	NA	----	----	NA	----	----	NA	----	----	NA	----	----	NA	10
NATURAL ATTENUATION PARAMETERS (mg/l)																		
NITRATE	0.12	----	----	0.18	<0.1	0.72	0.47	<0.1	0.13	0.42	<0.1	0.34	0.32	<0.1	0.38	0.3	<0.1	NA
SULFATE	13.0	19.0	170	6.7	5	44	35	42	50	52	5	27	36	33	39	4.5	41	NA
ALKALINITY	200	310	310	250	310	380	300	360	410	390	340	250	340	330	330	54	370	NA
TOTAL HARDNESS	240.0	310.0	380	280	430	430	420	490	550	520	640	310	360	510	440	22	500	NA
AMMONIA	0.45	0.34	1.1	0.44	0.82	0.12	----	<0.03	UJ	----	<0.03	----	----	<0.03	0.13	0.34	<0.03	NA
METHANE	1.300	1.300	6.3	4.4	1.3	0.63	0.55	0.44	0.026	0.016	0.0084	0.27	0.90	0.0970	0.055	----	0	NA
PARAMETERS MEASURED IN THE FIELD																		
FERROUS IRON	1.0	3.2	NM	1.3	2.5	2.8	1.6	1.2	0.6	0.4	1.8	1.2	0.9	2.9	0.2	0.0	2.1	NA
pH	7.11	7.01	6.8	6.90	6.83	5.15	7.82	6.98	4.89	6.93	7.40	4.65	7.12	6.82	7.27	6.99	7.55	NA
DISSOLVED OXYGEN	0.00	0.00	0	0.13	0.00	9.84	0.50	0.00	9.9	0.72	0.16	10.92	0.33	0.00	0	12.38	0.28	NA
OXIDATION REDUCTION POTENTIAL	-129	-166	-200	-248.8	-156	238	-35.2	-103	267	46.3	46.8	275	-48.9	-132	-51	112.3	-71	NA
CONDUCTIVITY	0.605	0.999	12.1	0.666	1.100	0	0.731	1.280	0	1.459	1.532	0	1.776	1.420	1.49	0.034	###	NA
FIELD OBSERVATIONS	Odor/ Sheen	Odor	Odor	Odor/sheen	Dye Visible/ Odor	Odor/sheen	----	----	----	----	----	----	----	----	----	----	----	----

NOTES:

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TABLE 1-2

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174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

WELL ID	**MW-105**					**MW-106**					**MW-107**					**NYSDEC**
Sample Date	**Nov-06**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Nov-06**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Nov-06**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**STANDARDS**
VOCs (ug/l)																
BENZENE	**110**	**86**	**6.2**	**3.3**	**16**	----	----	----	----	----	0.52J	----	----	----	----	1
ETHYL BENZENE	**300**	**260**	**120**	----	**8.6**	----	----	----	----	----	**30**	----	----	----	----	5
TOLUENE	----	----	NA	NA	NA	----	----	NA	NA	NA	----	----	NA	NA	NA	5
XYLENE	**480**	**430**	**260**	----	**14**	----	----	----	----	----	0.41J	----	0.27 J	----	----	5
MTBE	----	----	NA	NA	NA	0.34J	----	NA	NA	NA	----	----	NA	NA	NA	10
NATURAL ATTENUATION PARAMETERS (mg/l)																
NITRATE	0.11	0.29	0.21	----	<0.1	----	0.12	----	----	<0.1	1.1	2.6	2.1	0.41	0.54	NA
SULFATE	6.3	5.6	8.1	25	14	28	42	49	48	36	17	12	15	45	42	NA
ALKALINITY	270	420	380	320	360	420	340	390	340	340	290	100	200	190	180	NA
TOTAL HARDNESS	370	320	370	370	460	430	410	450	550	380	360	120	200	510	330	NA
AMMONIA	0.054	----	----	----	<0.03	UJ	----	----	----	<0.03	0.099	----	---	---	<0.03	NA
METHANE	3.3	7.8	2.8	1.5	0.51	0.14	0.07	0.051	0.28	0.045	0.29	----	0.0049	0.033	0.057	NA
PARAMETERS MEASURED IN THE FIELD																
FERROUS IRON	2.2	1.1	3.5	0.8	2.9	0	0.0	0.8	0.0	0.0	1.6	0.0	0.0	5.2	3.5	NA
pH	4.64	6.97	7.39	7.21	7.77	7.32	7.35	6.97	7.53	7.38	5	6.88	6.92	7.62	7.49	NA
DISSOLVED OXYGEN	11.09	0.38	0.29	2.95	0.38	0	0.19	0.23	0.26	0.14	10.45	7.57	4.89	2.57	2.24	NA
OXIDATION REDUCTION POTENTIAL	272	-66.1	-43.1	86.1	-107.1	-20	-58.7	-5.3	10.1	-6.0	255	99.8	21.4	-21.7	-17.7	NA
CONDUCTIVITY	0	0.567	817	0.956	1.128	1.66	0.558	1.404	0.850	0.854	0	0.490	0.845	0.915	1.238	NA
FIELD OBSERVATIONS	Odor/sheen	Odor	Odor	Oxidant in H2O	----	----	----	----	----	----	----	----	----	----	----	----

NOTES:

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TABLE 1-2

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174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

WELL ID	**MW-108**		**MW-109**		**MW-110**		**MW-111**				**MW-112**				**MW-113**		**MW-114**		**NYSDEC**
Sample Date	**Feb-08**	**Oct-09**	**Feb-08**	**Oct-09**	**Feb-08**	**Oct-09**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Feb-08**	**Oct-09**	**Feb-08**	**Oct-09**	**STANDARDS**
VOCs (ug/l)																			
BENZENE	----	----	----	----	----	----	----	----	----	----	----	**13**	**6.9**	**< 10**	----	----	----	----	1
ETHYL BENZENE	----	----	----	----	----	----	----	----	----	----	**410**	**250**	**300**	**48**	----	----	----	----	5
TOLUENE	----	NA	----	NA	----	NA	----	NA	NA	NA	----	NA	NA	NA	NA	NA	NA	NA	5
XYLENE	----	----	----	----	----	----	----	----	----	----	**740**	**480**	**170**	**<20**	----	----	----	----	5
MTBE	----	NA	----	NA	----	NA	----	NA	NA	NA	----	NA	NA	NA	NA	NA	NA	NA	10
NATURAL ATTENUATION PARAMETERS (mg/l)																			
NITRATE	0.39	<0.1	0.66	<0.1	----	<0.1	----	----	----	<0.1	----	----	----	1.4	----	<0.1	----	<0.1	NA
SULFATE	41	44	70	65	41	57	65	45	48	49	19	11	11	8.4	11	62	11	56	NA
ALKALINITY	400	380	410	340	370	380	350	360	330	360	370	360	330	340	330	470	330	350	NA
TOTAL HARDNESS	510	540	460	420	450	570	410	490	600	540	380	570	530	510	530	540	530	400	NA
AMMONIA	< 0.03	< 0.03	< 0.03	< 0.03	----	< 0.03	----	----	----	< 0.03	----	----	----	0.051	----	< 0.03	----	< 0.03	NA
METHANE	0.018	0.0082	0.28	0.0078	0.048	0.061	0.044	0.040	0.051	0.039	7.2	3	1.6	1.4	1.6	0.021	1.6	0.0044	NA
PARAMETERS MEASURED IN THE FIELD																			
FERROUS IRON	1.6	1.2	0.0	0.2	0.4	0.0	0.0	0.0	0.2	0.0	1.3	2.1	2.2	0.0	1.7	1.5	1.8	1.4	NA
pH	6.92	6.93	6.95	7.49	7.14	7.54	7.23	7.34	7.24	7.21	7.25	8.30	6.57	7.33	7.06	7.19	6.90	7.12	NA
DISSOLVED OXYGEN	0.39	0	0.04	0.68	0.11	0.17	0.10	0.28	0.33	0.15	0.42	0.16	0.37	0.26	0.30	0.00	0.14	0.00	NA
OXIDATION REDUCTION POTENTIAL	27.6	-61	162.5	59.1	0.4	30.7	14.7	22.3	28.8	27.9	-110.2	-74.6	-71.3	21.5	-57.8	-42.7	-43.3	-112	NA
CONDUCTIVITY	1.033	2.16	1.269	1	0.970	1.311	0.725	0.848	1.199	1.750	0.599	0.855	15.890	1.481	1.349	1.863	1.055	1.38	NA
FIELD OBSERVATIONS	----	----	----	----	----	----	----	----	----	----	Odor	Odor	Odor	Odor	----	----	artesian	artesian	----

NOTES:

ug/L = Micrograms per liter

VOCs - volatile organic compounds determined by USEPA Method 8260

NYSDEC Standards - NYS Division of Water Technical and Operational Guidance Series (1.1.1) 1998

The MTBE ground water standard is from NYSDEC's TAGM 8086

- Bold concentrations exceedance of the NYSDEC Standards or Guidance Value

J = Results greater than the reporting limit that are considered estimated.

UJ= Results less than the reporting limit that are considered estimated.

---- = the compound was not detected at a concentration above the laboratory reporting limit

<10 J- compound were not detected above the laboratory's reporting limit of 10 ug/L. The laboratory's reporting limit exceeds NYSDEC Standard for the compound so the concentration are estimated as below 10ug/l.

Natural Attenuation Parameters are used to characterize the physical, chemical and biological response of a hydrologic system to contamination.

Dissolved Oxygen, Oxidation Reduction Potential, pH and conductivity were measured in the field using a Horiba U-22 and flow through cell just prior to collecting samples.

Ferrous Iron concentration were measured using a HACH Test Kit

Ferrous Iron and DO are reported in mg/L

pH is reported in standard units

Oxidation Reduction Potential is reported in mV

Conductivity is reported in ms/cm

Odor = "Petroleum-like" odor

mg/L= Milligrams per liter

Sheen= Sheen on purge water and/or sample

A Enhanced Bioremediation Pilot Test was conducted in May 2009

TABLE 1-3

Summary of Soil Vapor Data - Ramtech Property
ERM 2009 Supplemental Investigation
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

Sample ID	**SV-06**	**SV-07**	**SV-08**	**Ambient**	**Outdoor 90th Percentile[1]**	**Indoor 90th Percentile[1]**
VOCs (ug/m^3)						
BENZENE	2.14	3.43	**12.10**	<0.79	4.3	15.0
ETHYL BENZENE	0.97	**3.12**	1.08	<0.39	1.1	7.4
m,p - XYLENE	0.90	**4.19**	1.14	<0.39	1.4	12.0
0 - XYLENE	0.57	**2.92**	0.61	<0.39	1.7	7.6

NOTES:

VOCs = volatile organic compounds determined by USEPA Method TO-17

---- = Below the Reportable Limit

ug/m3- micrograms per cubic meter

Ambient = Upwind ambient air background sample.

1- 90% of the analytical results from a NYSDOH study on the concentrations of background VOCs in indoor and outdoor air samples which were collected from homes heated with fuel oil, were below the reported concentration. The New York State does not have standards or guidance for BTEX in soil vapor, to put perspective on the data, the NYSDOH and NYSDEC often compare the soil vapor results to the NYSDOH's background database to determine if there is a potential source or potential risk for vapor intrusion within a building.

- The bolded concentrations exceed the background outdoor air 90th percentile value as noted in the NYSDOH study

FINAL

TABLE 2-1

COMPLIANCE WITH SCGs

HANCOCK AIR NATIONAL GUARD BASE

SYRACUSE, NEW YORK

NYSDEC SITE NUMBER 734054

ERM PROJECT NUMBER 0086335

CITATION	DESCRIPTION	TYPE	POTENTIAL APPLICABILITY TO DEVELOPING REMEDIAL ACTION OBJECTIVES	POTENTIAL APPLICABILITY TO EVALUATING REMEDIAL ACTION ALTERNATIVES
STANDARDS AND CRITERIA (1)				
6 NYCRR Part 364	Waste Transporter Permits	Action	Not applicable	This standard would relate to alternatives that involve waste removal.
6 NYCRR Part 370 through 373	Hazardous Waste Management Regulations	Action, Chemical	This standard relates to identification of hazardous waste at the Site. This along with 6 NYCRR Part 375 would be used to assess remedial needs for hazardous waste at the Site.	This standard would relate to the characterization and management of hazardous waste at the Site. This would include characterization of excavated soil at the Site.
6 NYCRR Part 376	Land Disposal Restrictions	Action, Chemical	Not applicable.	This standard relates to the management of hazardous waste removed during remedial action.
6 NYCRR Part 375-3 6 NYCRR Part 375-6	Brownfield Cleanup Program and Soil Cleanup Objectives	Action, Chemical	This standard along with 6 NYCRR Part 370 to 373 would be used to assess remedial needs for hazardous waste at the Site.	This standard relates to all Site remedial activities (i.e. remedy selection and remedial action).
OSHA; 29 CFR 1910	Guidelines/Requirements for Workers at Hazardous Waste Sites (Subpart 120) and Standards for Air Contaminants (Subpart 1).	Action	Not applicable.	May relate to certain remedial action activities

CITATION	*DESCRIPTION*	*TYPE*	*POTENTIAL APPLICABILITY TO DEVELOPING REMEDIAL ACTION OBJECTIVES*	*POTENTIAL APPLICABILITY TO EVALUATING REMEDIAL ACTION ALTERNATIVES*
OSHA; 29 CFR 1926	Safety and Health Regulations for Construction	Action	Not applicable	May relate to certain remedial action activities.
***Guidelines** (1)*				
TAGM HWR-94-4046	Determination of Soil Cleanup Objectives and Cleanup Levels	Chemical	Guidance is applicable for the development of remedial action objectives for Site soil.	Guidance is applicable for evaluating the effectiveness of a remedial alternative.
NYSDOH Community Air Monitoring Plan for Intrusive Activities	Requirements real-time monitoring for volatile organic compounds (VOCs) and particulates (i.e., dust)	Action, Chemical	Not Applicable.	Would relate to any intrusive remedial activities (soil excavation and disposal).
NYSDOH Guidance for Evaluating Soil Vapor Intrusion	Guidance in identifying and addressing existing and potential human exposures to contaminated subsurface vapors associated with known or suspected VOCs contamination.	Action, Chemical	Not Applicable	Guidance would be applicable for remedial action alternatives for buildings above impacted areas.

CITATION	*DESCRIPTION*	*TYPE*	*POTENTIAL APPLICABILITY TO DEVELOPING REMEDIAL ACTION OBJECTIVES*	*POTENTIAL APPLICABILITY TO EVALUATING REMEDIAL ACTION ALTERNATIVES*
NYSDEC TOGS 1.1.1	Ambient Water Quality Standards and Guidance Values	Action, Chemical	Guidance would be applicable for development of remedial action objectives for Site ground water and indirectly relate to developing remedial action objectives for Site soil.	Guidance would be applicable for remedial action alternatives that involve work associated with Site ground water.
TO BE CONSIDERED (TBCS) (2)				
NYSDEC *Draft* DER-10	Technical Guidance for Site Investigation and Remediation	Action	Draft guidance relates to development of remedial action objectives.	Relates to all Site remedial action activities.
USEPA Region III Risk Based Concentration Tables (RBCs), Industrial/Commercial	Risk-based concentrations for contaminants in soil at industrial sites	Chemical	Not Applicable	Guidance would be applicable for remedial alternatives and activities that involve direct contact with Site media.

GLOSSARY OF ACRONYMS

CFR	Code of Federal Regulations
DER	Division of Environmental Remediation
NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OSHA	Occupational Safety and Health
RBC	Risk Based Concentrations
SCG	Standards, Criteria and Guidance
TAGM	Technical and administrative Guidance Memorandum
TBC	To Be Considered Information
TOGS	Technical and Operational Guidance Series
TSCA	Toxic Substances Control Act
VOCs	Volatile Organic Compounds (VOCs)
USEPA	U. S. Environmental Protection Agency

Notes:

(1) Standards and Criteria were obtained from NYSDEC Draft DER-10, Technical Guidance for Site Investigation and Remediation, December 2002.

(2) Guidelines were obtained from NYSDEC Draft DER-10, Technical Guidance for Site Investigation and Remediation, December 2002.

(3) TBCs are defined in this report as regulations and guidance documents that are not identified NYSDEC Draft DER-10, Technical Guidance for Site Investigation and Remediation, December 2002.

TABLE 2-2

Chemicals of Potential Concern for Site Media
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

	Soil (Prior Source Removal IRA)	Soil (current)	Ground Water (Prior to 2006)	Ground Water (current)
Volatiles	Benzene	None	Benzene	Benzene
	Ethlybenzene		Toluene	Ethlybenzene
	Xylene		Ethlybenzene	Xylene
			Xylene	
			MTBE	

TABLE 2-3

Summary of Analytical and Field Testing Data for Site 15 prior to 2008 Source Area Excavation IRA

174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

WELL ID	SB-1	SB-2	SB-3	SB-4	SB-7	SB-10	SB-16	SB-17	SB-20	SB-22	SB-24	SB-27	SB-28	NYSDEC RSCO
Completion Depth Bgs (ft bgs)	10	10	10	15	10	10	10	10	15	15	15	15	15	NA
Depth of Saturated Soil (ft bgs)	8	7	8	8	8.5	9	9	9	9.5	8.5	8	8	9	NA
Depth of Peak Field Screening above GW (ppm)	312	143	714	0	1498	1754	66.2	628	3	525	46.8	1048	31.4	NA
Peak Field Screening above GW (ft bgs)	6	6.5	7	7	5	3	8	6	5	6	7.5	7	4	NA
Sample Depth (ft bgs)	2.5	6.5	7	7	5	3	8	6	13.5	8	8	7	4	NA
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	NA
Sheen Testing	None	None	---	---	Present	---	None	Present	---	---	---	---	Present*	NA
Sample Date/ Time	9/4/2007 10:50	9/4/2007 10:55	8/6/07-11:20	8/6/07-12:15	9/4/2007 11:00	8/6/07-13:40	9/4/2007 11:08	9/4/2007 11:12	8/7/2007 11:15	8/7/07-14:05	8/7/07-14:35	8/7/07-14:55	9/4/2007 11:19	NA
VOCs (ug/Kg)														
BENZENE	----	----	<20	<10	----	**670**	----	----	----	< 200	<10	<600	----	60
ETHYLBENZENE	----	----	<20	<10	----	**25,000**	----	----	----	< 200	<10	<600	----	1,000
TOLUENE	----	----	<20	<10	----	<600	----	----	----	< 200	<10	<600	----	700
XYLENE	----	----	<20	<10	----	**90,000**	----	----	----	< 200	<10	1,300	----	1,600
MTBE	----	----	<20	<10	----	<600	----	----	----	< 200	<10	<600	----	930
DIESEL RANGE ORGANICS (mg/kg)	----	----	<20J	----	----	----	----	----	50J	<20	< 20	<20	----	NS

WELL ID	SB-31	SB-32	SB-34	SB-36	SB-41	NYSDEC RSCO
Completion Depth Bgs (ft bgs)	15	15	15	20	15	NA
Depth of Saturated Soil (ft bgs)	8	7.5	7.5	7.5	7.5	NA
Depth of Peak Field Screening above GW (ppm)	16.1	0	8.7	0	928	NA
Peak Field Screening above GW (ft bgs)	2	7	6	7	4.5	NA
Sample Depth (ft bgs)	2.5	8	6	6.5	4.5	NA
Sample Matrix	Soil	Soil	Soil	Soil	Soil	NA
Sheen Testing	---	No	---	---	---	NA
Sample Date/ Time	8/8/07-9:10	9/4/2007 11:26	8/8/07-10:30	8/8/07-13:10	8/9/07 7:50	NA
VOCs (ug/Kg)						
BENZENE	<10	----	< 10	<10	< 700	60
ETHYLBENZENE	<10	----	< 10	<10	< 700	1,000
TOLUENE	<10	----	< 10	<10	< 700	700
XYLENE	<10	----	< 10	<10	790	1,600
MTBE	<10	----	< 10	<10	< 700	930
DIESEL RANGE ORGANICS (mg/kg)	----	----	----	----	< 20	NS

NOTES:

ug/ Kg = micrograms per kilogram

NYSDEC RSCO - NYSDEC Part 375- 6.8 (b) recommended soil clean up objective for the protection of ground water

VOCs - volatile organic compounds determined by USEPA Method 8260

---- = the sample was not analyzed for the compound or the test was not conducted at the location

NA - not applicable

NM - Not Measured

J = Estimated dection at a concentration above the method detection limit but below the reporting limit

- Bold white type with black background indicates exceedance of the NYSDEC RSCO

Yes- sheen/ residual product present when a soil water adjutation test was conducted

None- sheen/ residual product was not present when a soil water agitation test was conducted

* Sheen test on SB-28 was conducted on soil taken from below the water table; the soil was screened in the field at 2,167 ppm

TABLE 2-3

Summary of Analytical and Field Testing Data for Site 15 prior to 2008 Source Area Excavation IRA
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

TEMPORARY WELL ID	WP-207	WP-208	WP-209	WP-210	WP-211	NYSDEC STANDARDS
Completion Depth Bgs (ft bgs)	17	19	18	17.5	18	NA
Sample Matrix	Groundwater	Groundwater	Groundwater	Groundwater	Groundwater	NA
Depth of Saturated Soil (ft bgs)	8	8.5	8	9.3	8	NA
Depth of Sand Contact (ft bgs)	13.5	> 10	10.5	13.8	9	NA
Peak Field Screening in GW (ppm)	0	0	55	2493	0	NA
Depth of Peak Field Screening in GW (ft bgs)	---	---	12	14.5	---	NA
Screen Interval (ft bgs)	15-19	15-19	14-18	13.5-17.5	14-18	NA
Sample Date/ Time	8/6/07-12:30	8/7/08-10:15	8/8/07-8:45	8/8/07-11:15	8/8/07-15:00	NA
VOCs (ug/L)						
BENZENE	< 1	< 1	< 1	**22**	< 1	1
ETHYLBENZENE	< 1	< 1	< 1	**330**	< 1	5
TOLUENE	< 1	< 1	< 1	< 20	< 1	5
XYLENE	< 1	< 1	< 1	**1000**	< 1	5
MTBE	< 1	< 1	< 1	<20	< 1	10

NOTES:

ug/L = Micrograms per liter

NYSDEC Standards - NYS Division of Water Technical and Operational Guidance Series (1.1.1) 1998

The MTBE ground water standard is from NYSDEC's TAGM 4046

VOCs - volatile organic compounds determined by USEPA Method 8260

---- = the sample was not analyzed for the compound or the test was not conducted at the location

NA - not applicable

NM - Not Measured

J = Estimated dection at a concentration above the method detection limit but below the reporting limit

- Bold white type with black background indicates exceedance of the NYSDEC Standard or Guidance Value

WP- Water Profile Grab Sample collected with Geoprobe Hydropunch or SP-16 Grab Sampler

TABLE 2-4

Evaluation of Potential Remedial Technologies
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

TECHNOLOGY	DESCRIPTION	ABILITY TO MEET RAOs*	EFFECTIVENESS	IMPLEMENTABILITY	Technology Carried Forward?
Institutional Controls - Deed Restriction	This technology involves filing a deed restriction preventing the use of Site groundwater as drinking water.	This technology meets the following RAOs: SRAO1 and GWRAO1	This technology would need to be used in conjunction with other technologies to be effective	This technology may be difficult to implement. ANG does not own all the properties within the affected BEX plume, and cannot add restrictions to those property deeds. Deed restriction issues would have to be coordinated with several property owner's and therefore, would difficult it's implementability.	**No**
Institutional Controls - Part 5 of NYSDOH Sanitary Code	Part 5 of the New York State Department of Health State Sanitary Code prevents installation of a private potable water supply well in areas that are served by a public water supply system.	This technology meets the following RAOs: SRAO1 and GWRAO1	This technology would need to be used in conjunction with other technologies to be effective	All the properties within the BEX affected plume are supplied by a public water system, therefore, this part of the code is readily implementable and would continue to be enforced by NYSDOH. preventing contact with the BEX-affected groundwater.	**Yes**
Soil Excavation	This technology involves the excavation of the residual grossly affected soil identified in the Site 15 source area.	This technology meets the following RAOs: SRAO1, SRAO2, and GWRAO3	Excavation is a conventional technology that is expected to be effective for removal of grossly affected soil in the source area.	Soil excavation would require clearing of the area and mobilization of heavy equipment. No space constraints exist at the Site that would prevent mobilization of heavy equipment. This technology is, therefore, readily implementable.	**Yes**
Monitored Natural Attenuation (Ground Water Monitoring)	Relies on natural processes to breakdown ground water contaminants. Natural attenuation processes include physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce mass, toxicity, mobility, volume.	This technology meets the following RAOs: GWRAO1, and GWRAO2	Evaluation of contaminant trends and geochemical parameters indicates that natural attenuation through aerobic and anaerobic biodegradation is occurring within the plume. On site, groundwater concentrations are showing decreasing trends and MNA will be an effective technology for meeting RAOs within an acceptable timeframe, especially when combined with additional source area soil removal. Offsite, however, the rate of attenuation may not be sufficient to achieve RAOs within an acceptable timeframe.	MNA is readily implementable. Demonstration of MNA requires significant sampling frequency and parameters, which is currently underway at the site.	**Yes**
Aerobic Biological Treatment using Solid Peroxide.	The solid peroxide is applied as a slurry through injection wells or direct push points arrayed as a grid for treatment of a source zone or dissolved plume, or as rows of points to form a biological barrier against further downgradient flux of contaminants. Solid peroxide hydrolyzes to release oxygen that will support aerobic biological degradation of the VOCs. Solid peroxides, if applied in sufficient mass, typical persist for six months to three years before reapplication is required.	This technology meets the following RAOs: GWRAO1, GWRAO2, GWRAO4 and GWRAO5	The biodegradation evaluation concluded that aerobic biological degradation is occurring at the site, but is limited by the availability of oxygen. This technology can effectively treat the dissolved plume, residual source areas (after grossly contaminated material is removed), and downgradient flux of contaminants.	The equipment and construction methods required for the injection of peroxide slurry through wells or direct-push points are readily available and easily implemented. Preferential flow paths and areas of low conductivity may limit the ability to distribute the peroxide slurry radially away from the injection point and the solid peroxide may need to be injected more frequently than projected by vendors (once every 2 to 3 years). These limitations can be overcome by conducting a pilot test to evaluate effectiveness parameters and/or by reducing the grid spacing for the injections. This technology can also be easily scaled up to treat additional areas or scaled down as the plume shrinks over time.	**Yes**
Aerobic Biological Treatment using Air Sparging	The injection of air under pressure into wells screened at the bottom of the impacted aquifer unit will provide oxygen to support aerobic biological degradation of the VOCs. The wells can be arrayed as a grid for treatment of a source zone or dissolved plume, or as rows of points to form a biological barrier against further downgradient flux of contaminants. A soil vapor extraction system would be used to capture VOCs that are stripped by the sparge air but not completely degraded.	This technology meets the following RAOs: GWRAO1, GWRAO2, GWRAO4 and GWRAO5	The biodegradation evaluation concluded that aerobic biological degradation is occurring at the site, but is limited by the availability of oxygen. This technology can effectively treat the dissolved plume, residual source areas (after grossly contaminated material is removed), and downgradient flux of contaminants.	The equipment and construction methods required for air sparging are readily available and easily implemented. Preferential flow paths and areas of low conductivity may limit the ability to distribute the air radially away from the injection point; however, the effective radius of influence can be determined by pilot testing. Although the number of operating sparge points can be reduced over time as the plume shrinks, this technology has less flexibility to be scaled up or down over time without incurring additional capital expenses. Capital and O&M expenses for air sparging technologies are generally much larger than technologies involving direct push injections.	No
Enhanced Anaerobic Bioremediation	Anaerobic biodegradation of the VOCs can be enhanced by the addition of an anaerobic electron acceptor, which is typically either nitrate or sulfate. Nitrate and sulfate salts are highly soluble in water and can be provided through either batch or continuous addition. This technology can be used either for source, dissolved plume or barrier treatment.	This technology would not meet the applicable GW RAOs	The biodegradation evaluation concluded that anaerobic biological degradation through sulfate reduction and iron reduction is occurring at the site and that these are the main naturally occurring processes. Based on this evaluation, anaerobic bioremediation using sulfate reduction would be an effective technology to treat the dissolved plume on site, but the offsite rate of degradation might not be sufficient to prevent the continued migration in the more permeable zone. This technology may also be less effective for treating benzene, since benzene is more recalcitrant to anaerobic biological degradation than ethylbenzene or xylenes.	The equipment and construction methods required for the direct-push injection of sulfate or nitrate are readily available and easily implemented. Preferential flow paths and areas of low conductivity may limit the ability to distribute sulfate radially away from the injection point and the rate of consumption of sulfate can not be easily predicted. However, the effective radius of influence persistence of sulfate can be determined by pilot testing.	No
Permanganate Oxidation	This technology includes in situ chemical oxidation of VOCs using potassium permanganate, with follow-up MNA as necessary	This technology may not meet the following RAOs, GWRAO1, GWRAO2, GWRAO4 and GWRAO5	Permanganate is an effective oxidant for the treatment of VOCs such as ethylbenzene and xylenes, but is less effective for the treatment of benzene.	The equipment and construction methods required for the direct-push injection of potassium permanganate are readily available and easily implemented. Preferential flow paths and areas of low conductivity will dictate where injected potassium permanganate will flow, which could result in portions of the treatment area not receiving injected material. This can be overcome by conducting a pilot test to evaluate effectiveness parameters and/or by reducing the grid spacing for the direct-push injections.	No

(*) **Soil RAOs**

SRAO1 - Prevent ingestion, direct contact, and/or inhalation of/with soil that poses a risk to public health and the environment given the intended use of the Site; and
SRAO2 - Prevent inhalation of or exposure from COPCs volatilizing from soil that poses a risk to public health and the environment given the intended use of the Site.

(*) **Ground water RAOs**

GWRAO1 - Prevent exposure to contaminated ground water containing BTEX concentrations above the NYSDEC Ambient Water Quality Standards and Guidance Values (that poses a risk to public health and the environment given the intended use of the Site)
GWRAO2 - Prevent or minimize further migration of the contaminant plume (plume containment).
GWRAO3 - Prevent or minimize further migration of contaminants from source materials to ground water (source control).
GWRAO4 - Enhance the natural process for the attenuation of BTEX compounds on-site and off-site.
GWRAO5 - Prevent inhalation of or exposure from COPCs volatilizing from groundwater that poses a risk to public health and the environment given the intended use of the Site.

TABLE 3-1

Confirmation Sample Results
ERP Site 15 Source Area Soil Removal
174th Fighter Wing, New York Air National Guard
Syracuse, New York

Location	Date Sampled	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Total MTBE
ANG- SC-01	8/12/2008	<50	<50	<50	75	<50
ANG-SC- DUP-01	8/12/2008	<30	<30	<30	<30	<30
ANG- SC-02	8/12/2008	<8	<8	<8	<8	<8
ANG- SC-03	8/12/2008	<10	<10	<10	<10	<10
ANG- SC-04	8/12/2008	<8	<8	<8	<8	<8
ANG- SC-05	8/13/2008	<5	<5	<5	<5	<5
ANG- SC-06	8/13/2008	<40	<40	<40	<40	<40
ANG- SC-07	8/13/2008	**460**	<40	**6,300 E**	**6,400 E**	<40
ANG- SC-08	8/14/2008	<7	<7	<7	<7	<7
ANG- SC-09	8/14/2008	<40	<40	320	1200	<40
ANG- SC-10	8/14/2008	<40	<40	<40	<40	<40
ANG- SC-11	8/19/2008	<8	<8	<8	<8	29
ANG- SC-12	8/19/2008	260	<60	**19,000 E**	**18,000 E**	230
ANG- SC-13	8/19/2008	<8	<8	<8	<8	31
ANG- SC-14	8/20/2008	<8	<8	<8	<8	<8
ANG- SC-15	8/20/2008	<7	<7	<7	<7	<7
ANG- SC-16	8/20/2008	<50	<50	**1,800**	700	<50
ANG- SC-17	8/20/2008	**<80**	<80	<80	420	<80
ANG- SC-18	8/21/2008	<10	<10	<10	<10	<10
ANG- SC-19	8/21/2008	<40	<40	**1,300**	<40	<5
ANG- SC-20	8/21/2008	<5	<5	<5	<5	<5
ANG- SC-21	8/21/2008	<5	<5	<5	<5	5.3
ANG- SC-22	8/21/2008	<9	<9	<9	<9	<9
Part 375 RSCO		60	700	1,000	1,600	930

Notes

Bold = Result exceeds noted Cleanup Level.

All concentrations reporting in micrograms per kilogram

Part 375 RSCO = NYSDEC Part 375-6.8(b) Recommended Soil Cleanup Objective for Protection of Groundwater.

E= Reported concentration should be considered an estimate, beause the concentration exceeded the linear range of the instrument

TABLE 3-1

Confirmation Sample Results
ERP Site 15 Source Area Soil Removal
174th Fighter Wing, New York Air National Guard
Syracuse, New York

Location	Date Sampled	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Total MTBE
ANG- SC-23	8/21/2008	<10	<10	**2,100 E**	<10	16
ANG-SC- DUP-02	8/21/2008	<30	<30	**1,000**	<30	<30
ANG- SC-24	8/21/2008	<9	<9	<9	<9	<9
ANG- SC-25	8/25/2008	<10	<10	<10	<10	<10
ANG- SC-26	8/25/2008	<10	<10	<10	<10	<10
ANG- SC-27	8/25/2008	<20	<20	<20	<20	<20
ANG- SC-28	8/25/2008	<10	<10	<10	<10	<10
ANG- SC-29	8/25/2008	<20	<20	<20	<20	<20
ANG- SC-30	8/25/2008	<10	<10	40	91	<10
ANG- SC-31	8/25/2008	**<90**	<90	160	550	<90
ANG- SC-32	8/25/2008	<50	<50	210	290	<50
Part 375 RSCO		60	700	1,000	1,600	930

Notes

Bold = Result exceeds noted Cleanup Level.

All concentrations reporting in micrograms per kilogram

Part 375 RSCO = NYSDEC Part 375-6.8(b) Recommended Soil Cleanup Objective for Protection of Groundwater.

E= Reported concentration should be considered an estimate, beause the concentration exceeded
the linear range of the instrument

FINAL

TABLE 3-2

Summary of Select Groundwater Data (2005 through 2009) Applicable to the Enhanced Bioremediation Pilot Test

174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

WELL ID	**MW-19**							**MW-105**					**MW-106**					**NYSDEC**
	Pre-PT-Treatment					**Post-PT-Treatment**		**Pre-PT-Treatment**			**Post-PT-Treatment**		**Pre-PT-Treatment**			**Post-PT-Treatment**		
Sample Date	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Nov-06**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Nov-06**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**STANDARDS**
VOCs (ug/l)																		
BENZENE	**28**	**33**	**17J**	----	0.71 J	**6**	**< 10**	**110**	**86**	**6.2**	**3.3**	**16**	----	----	----	----	----	1
ETHYL BENZENE	**300**	**610**	**270**	**8.5**	**17**	**410**	**380**	**300**	**260**	**120**	----	**8.6**	----	----	----	----	----	5
TOLUENE	----	----	----	----	NA	NA	NA	----	----	NA	NA	NA	----	----	NA	NA	NA	5
XYLENE	**650**	**860**	**460**	**9**	**20**	**760**	**420**	**480**	**430**	**260**	----	**14**	----	----	----	----	----	5
MTBE	----	----	----	----	NA	NA	NA	----	----	NA	NA	NA	0.34J	----	NA	NA	NA	10
NATURAL ATTENUATION PARAMETERS (mg/l)																		
NITRATE	0.19	----	----	0.28	----	----	<0.1	0.11	0.29	0.21	----	<0.1	----	0.12	----	----	<0.1	NA
SULFATE	15.0	----	11	25.0	20.0	6.7	4.9	6.3	5.6	8.1	25	14	28	42	49	48	36	NA
ALKALINITY	350	330	240	410	330	330	340	270	420	380	320	360	420	340	390	340	340	NA
TOTAL HARDNESS	340	350	330	350	400	560	550	370	320	370	370	460	430	410	450	550	380	NA
AMMONIA	----	----	0.75J	----	----	0.077	0.16	0.054	----	----	----	<0.03	UJ	----	----	----	<0.03	NA
METHANE	3.400	3.500	----	0.99	0.61	0.98	3	3.3	7.8	2.8	1.5	0.51	0.14	0.07	0.051	0.28	0.045	NA
PARAMETERS MEASURED IN THE FIELD																		
FERROUS IRON	----	4.100	2.2	2	1.7	2.7	1.9	2.2	1.1	3.5	0.8	2.9	0	0.0	0.8	0.0	0.0	NA
pH	6.78	6.68	4.66	6.37	7.1	6.64	8.21	4.64	6.97	7.39	7.21	7.77	7.32	7.35	6.97	7.53	7.38	NA
DISSOLVED OXYGEN	0.00	0.00	10.95	0.88	0.71	0.29	0.21	11.09	0.38	0.29	2.95	0.38	0	0.19	0.23	0.26	0.14	NA
OXIDATION REDUCTION POTENTIAL	-79	-101	267	23.7	11.6	-33.4	-132.6	272	-66.1	-43.1	86.1	-107.1	-20	-58.7	-5.3	10.1	-6.0	NA
CONDUCTIVITY	1.210	0.91	0	1.260	0.997	1.052	1.450	0	0.567	817	0.956	1.128	1.66	0.558	1.404	0.850	0.854	NA
FIELD OBSERVATIONS	----	----	----	----	----	Odor	----	Odor/sheen	Odor	Odor	Oxidant in H2O	----	----	----	----	----	----	----

NOTES:

ug/L = Micrograms per liter
VOCs - volatile organic compounds determined by USEPA Method 8260
A Enhanced Bioremediation Pilot Test was conducted in May 2009
NYSDEC Standards - NYS Division of Water Technical and Operational Guidance Series (1.1.1) 1998
The MTBE ground water standard is from NYSDEC's TAGM 8086
- Bold concentrations exceedance of the NYSDEC Standards or Guidance Value
J = Results greater than the reporting limit that are considered estimated.
UJ= Results less than the reporting limit that are considered estimated.
---- = the compound was not detected at a concentration above the laboratory reporting limit
<10 J- compound were not detected above the laboratory's reporting limit of 10 ug/L. The laboratory's reporting limit exceeds NYSDEC Standard for the compound so the concentration are estimated as below 10ug/l.
Natural Attenuation Parameters are used to characterize the physical, chemical and biological response of a hydrologic system to contamination.
Dissolved Oxygen, Oxidation Reduction Potential, pH and conductivity were measured in the field using a Horiba U-22 and flow through cell just prior to collecting samples.
Ferrous Iron concentration were measured using a HACH Test Kit

Ferrous Iron and DO are reported in mg/L
pH is reported in standard units
Oxidation Reduction Potential is reported in mV
Conductivity is reported in ms/cm
Odor = "Petroleum-like" odor
mg/L= Milligrams per liter
Sheen= Sheen on purge water and/or sample

FINAL

TABLE 3-2

Summary of Select Groundwater Data (2005 through 2009) Applicable to the Enhanced Bioremediation Pilot Test
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

WELL ID	**MW-107**					**MW-111**				**MW-112**				**MW-113**		**MW-114**		**NYSDEC**
	Pre-PT-Treatment			**Post-PT-Treatment**		**Pre-PT-Treatment**		**Post-PT-Treatment**		**Pre-PT-Treatment**		**Post-PT-Treatment**		**Pre-PT-Treatment**	**Post-PT-Treatment**	**Pre-PT-Treatment**	**Post-PT-Treatment**	
Sample Date	**Nov-06**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Feb-08**	**Oct-09**	**Feb-08**	**Oct-09**	**STANDARDS**
VOCs (ug/l)																		
BENZENE	0.52J	----	----	----	----	----	----	----	----	----	**13**	**6.9**	**< 10**	----	----	----	----	1
ETHYL BENZENE	**30**	----	----	----	----	----	----	----	----	**410**	**250**	**300**	**48**	----	----	----	----	5
TOLUENE	----	----	NA	NA	NA	----	NA	NA	NA	----	NA	NA	NA	NA	NA	NA	NA	5
XYLENE	0.41J	----	0.27 J	----	----	----	----	----	----	**740**	**480**	**170**	**<20**	----	----	----	----	5
MTBE	----	----	NA	NA	NA	----	NA	NA	NA	----	NA	NA	NA	NA	NA	NA	NA	10
NATURAL ATTENUATION PARAMETERS (mg/l)																		
NITRATE	1.1	2.6	2.1	0.41	0.54	----	----	----	<0.1	----	----	----	1.4	----	<0.1	----	<0.1	NA
SULFATE	17	12	15	45	42	65	45	48	49	19	11	11	8.4	11	62	11	56	NA
ALKALINITY	290	100	200	190	180	350	360	330	360	370	360	330	340	330	470	330	350	NA
TOTAL HARDNESS	360	120	200	510	330	410	490	600	540	380	570	530	510	530	540	530	400	NA
AMMONIA	0.099	----	---	---	<0.03	----	----	----	< 0.03	----	----	----	0.051	----	< 0.03	----	< 0.03	NA
METHANE	0.29	----	0.0049	0.033	0.057	0.044	0.040	0.051	0.039	7.2	3	1.6	1.4	1.6	0.021	1.6	0.0044	NA
PARAMETERS MEASURED IN THE FIELD																		
FERROUS IRON	1.6	0.0	0.0	5.2	3.5	0.0	0.0	0.2	0.0	1.3	2.1	2.2	0.0	1.7	1.5	1.8	1.4	NA
pH	5	6.88	6.92	7.62	7.49	7.23	7.34	7.24	7.21	7.25	8.30	6.57	7.33	7.06	7.19	6.90	7.12	NA
DISSOLVED OXYGEN	10.45	7.57	4.89	2.57	2.24	0.10	0.28	0.33	0.15	0.42	0.16	0.37	0.26	0.30	0.00	0.14	0.00	NA
OXIDATION REDUCTION POTENTIAL	255	99.8	21.4	-21.7	-17.7	14.7	22.3	28.8	27.9	-110.2	-74.6	-71.3	21.5	-57.8	-42.7	-43.3	-112	NA
CONDUCTIVITY	0	0.490	0.845	0.915	1.238	0.725	0.848	1.199	1.750	0.599	0.855	15.890	1.481	1.349	1.863	1.055	1.38	NA
FIELD OBSERVATIONS	----	----	----	----	----	----	----	----	----	Odor	Odor	Odor	Odor	----	----	artesian	artesian	----

NOTES:

ug/L = Micrograms per liter

VOCs - volatile organic compounds determined by USEPA Method 8260

A Enhanced Bioremediation Pilot Test was conducted in May 2009

NYSDEC Standards - NYS Division of Water Technical and Operational Guidance Series (1.1.1) 1998

The MTBE ground water standard is from NYSDEC's TAGM 8086

- Bold concentrations exceedance of the NYSDEC Standards or Guidance Value

J = Results greater than the reporting limit that are considered estimated.

UJ= Results less than the reporting limit that are considered estimated.

---- = the compound was not detected at a concentration above the laboratory reporting limit

<10 J- compound were not detected above the laboratory's reporting limit of 10 ug/L. The laboratory's reporting limit exceeds NYSDEC Standard for the compound so the concentration are estimated as below 10ug/l.

Natural Attenuation Parameters are used to characterize the physical, chemical and biological response of a hydrologic system to contamination.

Dissolved Oxygen, Oxidation Reduction Potential, pH and conductivity were measured in the field using a Horiba U-22 and flow through cell just prior to collecting samples.

Ferrous Iron concentration were measured using a HACH Test Kit

Ferrous Iron and DO are reported in mg/L

pH is reported in standard units

Oxidation Reduction Potential is reported in mV

Conductivity is reported in ms/cm

Odor = "Petroleum-like" odor

mg/L= Milligrams per liter

Sheen= Sheen on purge water and/or sample

TABLE 3-3

Remedial Alternative 2 Cost Estimate
Excavation and Off-Site Disposal of Soil + MNA
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

Item Description	Units	Unit Cost	Quantity	Cost	Ref
<u>PREVIOUSLY INCURRED CAPITAL COSTS</u>					1
Interim Remedial Measure No. 1 - Excavation and Off-Site Disposal of Source Area (Soil)					
	ls	$490,000	1	$ 490,000	2
Total Remedial Action Previously Incurred Capital Costs (A)				$ 490,000	
<u>CAPITAL COSTS</u>					
Common Action No. 1 - Indoor Air Investigation (Ramtech)	ls	$ 5,000	1	$ 5,000	3
Grand Total				$ 5,000	
Mobilization/Demobilization (5%)				$ 250	4
Project Management (10%)				$ 500	4
Remedial Design (20%)				$ 1,000	4
Construction Management (15%)				$ 750	4
Reporting (8%)				$ 400	4
Contingency (10%)				$ 500	4
Total Remedial Action Capital Costs To Be Incurred (B)				***$ 8,400***	

TABLE 3-3

Remedial Alternative 2 Cost Estimate
Excavation and Off-Site Disposal of Soil + MNA
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

LONG TERM O&M COSTS

Ground Water Sampling and Reporting (Monitoring Natural Attenuation, MNA)

Yearly monitoring and reporting for 5 years.Analysis of Site COPC parameters, and natural attenuation parameters annually ($25,000 per year, 2% inflation, 7% dicount rate)	ls	$	108,237	1	$	108,237	5
Monitoring subsequently every other year for 25 years for Site COPC parameters, and natural attenuation parameters ($12500 per year, 2% inflation, 7% dicount rate)	ls	$	138,037	1	$	138,037	5
Subtotal MNA Present Value					**$**	**246,274**	
Total Present Value of Long Term Operation and Maintenance Costs (C)					*$*	***246,274***	
TOTAL PRESENT WORTH OF COSTS (B+C)					**$**	**254,674**	

Notes:

1 Portions of the Remedial Alternative that have been completed at the time this FFS was prepared.
Incurred costs will not be used to calculate EPA recommended percentage based technical services amounts
2 Portion of the Remedial Alternative already completed per the approved Work Plan (ERM, 2008). Approximate costs incurred to date. Costs include reporting.
3 Assuming two (2) sub-slab vapor samples, two (2) indoor air samples, and two (2) outdoor background air samples
4 Recommended Percentages for Technical Services (USEPA, 2000)
5 One round of sampling includes sampling of 20 monitoring wells + 3 QA/QC samples, average of $340 dollars per analytical sample
$11,000 in equipment rental and labor and $4500 in MNA evaluation and reporting, resulting in approximately $25,000 every sampling event

TABLE 3-4

Remedial Alternative 3 Cost Estimate
Excavation and Off-Site Disposal of Soil + ISCO Pilot Study + Focused ISCO + MNA
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

Item Description	Units	Unit Cost	Quantity	Cost	Ref
PREVIOUSLY INCURRED CAPITAL COSTS					1
Interim Remedial Measure No. 1 - Excavation and Off-Site Disposal of Source Area (Soil)	ls	$490,000	1	$ 490,000	2
Interim Remedial Measure No. 2 - Enhanced Bioremediation Pilot Study via ISCO	ls	$117,000	1	$ 117,000	2
Total Remedial Action Previously Incurred Capital Costs (A)				$ 607,000	
CAPITAL COSTS					
Common Action No. 1 - Indoor Air Investigation (Ramtech)	ls	$ 5,000	1	$ 5,000	3
Focused Enhanced Aerobic Bioremediation via ISCO					
Field Subcontractor Work	ls	$ 82,528	1	$ 82,528	4
Laboratory	ls	$ 1,500	1	$ 1,500	5
Bio-chemical product	lbs	$ 8.25	1800	$ 14,850	6, 7
Surveying	ls	$ 3,000	1	$ 3,000	5
Expenses, H&S, Equipment Rental	ls	$ 4,523	1	$ 4,523	5
Grand Total				$ 106,401	
Mobilization/Demobilization (5%)				$ 5,320	8
Project Management (8%)				$ 8,512	8
Remedial Design (15%)				$ 15,960	8
Construction Management (10%)				$ 10,640	8
Reporting (8%)				$ 8,512	8
Contingency (10%)				$ 10,640	8
Total Remedial Action Capital Costs To Be Incurred (B)				***$ 165,985***	

TABLE 3-4

Remedial Alternative 3 Cost Estimate
Excavation and Off-Site Disposal of Soil + ISCO Pilot Study + Focused ISCO + MNA
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

LONG TERM O&M COSTS

Follow-up ISCO Injections Follow-up injections in 22 of the original injection points (43) at year 2. A follow-up round is estimated to be 50% ($53,200) of the original capital costs for 46 injections ($106,401). 2% inflation, 7% dicount rate assumed	ls	$	48,254	1	**$**	**48,254**	
Ground Water Sampling and Reporting (Monitoring Natural Attenuation, MNA)							
Quarterly monitoring and reporting for 4 years.Analysis of Site COPC parameters, and natural attenuation parameters annually $100,000 per year, 2% inflation, 7% dicount rate)	ls	$	354,595	1	$	354,595	9
Yearly monitoring subsequently every year for 6 years for Site COPC parameters, and natural attenuation parameters ($25,000 per year, 2% inflation, 7% dicount rate)	ls	$	104,395	1	$	104,395	9
Subtotal MNA Present Value					**$**	**458,990**	
Total Present Value of Long Term Operation and Maintenance Costs (C)					***$***	***507,244***	
TOTAL PRESENT WORTH OF COSTS (B+C)					**$**	**673,229**	

Notes:

1 Portions of the Remedial Alternative that have been completed at the time this FFS was prepared.
Incurred costs will not be used to calculate EPA recommended percentage based technical services amounts
2 Portion of the Remedial Alternative already completed per the approved Work Plan (ERM, 2008). Approximate costs incurred to date. Costs include reporting.
3 Assuming two (2) sub-slab vapor samples, two (2) indoor air samples, and two (2) outdoor background air samples
4 Environmental Cleanup Solutions provided a quote of $38,400 dated May 16 2007 for injection of the selected bio-chemical of up to 20 injection points.
Estimated cost for 43 injection points was calculated using a simple linear correlation with the available quote for 20 points.
5 ERM estimate based on prior experience with comparable tasks
6 Estimate based on quote provided by FMC technologies for oxidation product
7 Assumes 43 injection points will be required at 50 lbs of solid peroxide product
8 Recommended Percentages for Technical Services (USEPA, 2000)
9 One round of sampling includes sampling of 20 monitoring wells + 3 QA/QC samples, average of $340 dollars per analytical sample
$11,000 in equipment rental and labor and $4500 in MNA evaluation and reporting, resulting in approximately $25,000 every sampling event

TABLE 3-5

Remedial Alternative 4 Cost Estimate
Excavation and Off-Site Disposal of Soil + ISCO Pilot Study + Expanded ISCO + MNA
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

Item Description	Units	Unit Cost	Quantity	Cost	Ref
PREVIOUSLY INCURRED CAPITAL COSTS					1
Interim Remedial Measure No. 1 - Excavation and Off-Site Disposal of Source Area (Soil)	ls	$490,000	1	$ 490,000	2
Interim Remedial Measure No. 2 - Enhanced Bioremediation Pilot Study via ISCO	ls	$117,000	1	$ 117,000	2
Total Remedial Action Previously Incurred Capital Costs (A)				$ 607,000	
CAPITAL COSTS					
Common Action No. 1 - Indoor Air Investigation (Ramtech)	ls	$ 5,000	1	$ 5,000	3
Expanded Enhanced Aerobic Bioremediation via ISCO					
Field Subcontractor Work	ls	$ 203,441	1	$ 203,441	4
Laboratory	ls	$ 1,500	1	$ 1,500	5
Bio-chemical product	lbs	$ 8.25	5000	$ 41,250	6, 7
Surveying	ls	$ 3,000	1	$ 3,000	5
Expenses, H&S, Equipment Rental	ls	$ 4,523	1	$ 4,523	5
Grand Total				$ 253,714	
Mobilization/Demobilization (5%)				$ 12,686	8
Project Management (8%)				$ 20,297	8
Remedial Design (15%)				$ 38,057	8
Construction Management (10%)				$ 25,371	8
Reporting (8%)				$ 20,297	8
Contingency (20%)				$ 50,743	10
Total Remedial Action Capital Costs To Be Incurred (B)				***$ 421,164***	

TABLE 3-5

Remedial Alternative 4 Cost Estimate
Excavation and Off-Site Disposal of Soil + ISCO Pilot Study + Expanded ISCO + MNA
174th Fighter Wing
New York Air National Guard
Hancock Air National Guard Base
Syracuse, New York

LONG TERM O&M COSTS							
Follow-up ISCO Injections	ls	$	115,062	1	**$**	**115,062**	
Follow-up injections in 53 of the original injection points (106) at year 2. A follow-up round is estimated to be 50% ($126,856) of the original capital costs for 106 injections ($253,714). 2% inflation, 7% dicount rate assumed							
Ground Water Sampling and Reporting (Monitoring Natural Attenuation, MNA)							
Quarterly monitoring and reporting for 3 years. Analysis of Site COPC parameters, and natural attenuation parameters annually $100,000 per year, 2% inflation, 7% dicount rate)	ls	$	272,325	1	$	272,325	9
Yearly monitoring subsequently every year for 7 years for Site COPC parameters, and natural attenuation parameters ($25,000 per year, 2% inflation, 7% dicount rate)	ls	$	124,962	1	$	124,962	9
Subtotal MNA Present Value					**$**	**397,287**	
Total Present Value of Long Term Operation and Maintenance Costs (C)					***$***	***512,349***	
TOTAL PRESENT WORTH OF COSTS (B+C)					**$**	**933,514**	

Notes:

1 Portions of the Remedial Alternative that have been completed at the time this FFS was prepared.
Incurred costs will not be used to calculate EPA recommended percentage based technical services amounts
2 Portion of the Remedial Alternative already completed per the approved Work Plan (ERM, 2008). Approximate costs incurred to date. Costs include reporting.
3 Assuming two (2) sub-slab vapor samples, two (2) indoor air samples, and two (2) outdoor background air samples
4 Environmental Cleanup Solutions provided a quote of $38,400 dated May 16 2007 for injection of the selected bio-chemical of up to 20 injection points.
Estimated cost for 106 injection points was calculated using a simple linear correlation with the available quote for 20 points.
5 ERM estimate based on prior experience with comparable tasks
6 Estimate based on quote provided by FMC technologies for oxidation product
7 Assumes 106 injection points will be required at 50 lbs of solid peroxide product
8 Recommended Percentages for Technical Services (USEPA, 2000)
9 One round of sampling includes sampling of 20 monitoring wells + 3 QA/QC samples, average of $340 dollars per analytical sample
$11,000 in equipment rental and labor and $4500 in MNA evaluation and reporting, resulting in approximately $25,000 every sampling event
10 Contingency estimated at 20% to cover larger uncertainty regarding increased number of injection points needed (106 for Alternative 4 versus 46 in Alternative 3)

APPENDIX A

BIOREMEDIATION EVALUATION

Bioremediation Evaluation (Revised – March 2010)

Site 15

174th Fighter Wing Air National Guard

Hancock Field, Syracuse, NY

March 2010

TABLE OF CONTENTS

ATTACHEMENTS

1.0 BIODEGRADATION EVALUATION

This Biodegradiation Evaluation Report has been prepared for Site 15 at the 174th Fighter Wing (FW) of the New York Air National Guard (ANG) in Syracuse, New York (the Site). The report was prepared in support of the Feasibility Study Report being completed for the SIte as part of the ANG Environmental Restoration Program (ERP). Included in the evaluation are an assessment of natural attenuation through biodegradation and the results of the bioremediation pilot testing.

1.1 NATURAL ATTENUATION OF BEX

Benzene, ethylbenzene and xylenes naturally attenuate in the environment through multiple mechanisms including advection, dispersion, adsorption, volatilization and degradation. The physical mechanisms of advection, dispersion and adsorption result in the attenuation of concentration in groundwater with distance, but do not remove mass. Volatilization removes mass from the soil and groundwater into the atmosphere where photodegradation can occur.

The major mass removal processes for BEX and other hydrocarbons are aerobic and anaerobic biodegradation. Most aliphatic and aromatic hydrocarbons (e.g. BEX) are readily biodegraded under aerobic conditions by naturally occurring microorganisms utilizing oxygen as the electron acceptor. The final end-products of this biodegradation process are carbon dioxide and water. Since oxygen recharge at most sites is slow relative to the rate of depletion due to biodegradation, aerobic biodegradation of hydrocarbons results in the depletion of oxygen from groundwater and unsaturated zone soils with the production of carbon dioxide. As oxygen is depleted, subsurface conditions become anaerobic and the redox potential decreases. As the redox potential drops below 100 millivolts, the major biodegradation processes shift to anaerobic electron acceptors. Nitrate is generally the first anaerobic electron acceptor to be utilized by facultative anaerobic bacteria to support biodegradation of hydrocarbons by nitrate reduction. Once nitrate has been consumed, ferric iron (Fe^{+3}) and manganese are utilized as anaerobic electron acceptors and converted to their reduced, and more soluble, forms. As the redox potential drops further, hydrocarbon biodegradation through sulfate reduction occurs. At redox potentials below about –100 mV, methanogenic biodegradation occurs utilizing electron acceptors such as carbon dioxide and producing methane.

The occurrence of natural attenuation of BEX and hydrocarbons can be document in several ways. The primary lines of evidence include plume stability and concentration trends over time or distance from the source.

Secondary evidence of natural attenuation by biodegradation can be obtained by monitoring the behavior of electron acceptors, redox conditions, biodegradation products and other parameters across the plume. If sufficient information can be gathered, the mass of hydrocarbons consumed can be correlated with the mass of electron acceptors consumed and products produced.

1.2 LINES OF EVIDENCE FOR NATURAL ATTENUATION AT THE SITE

Evaluation of natural attenuation includes assessment of multiple lines of evidence (USEPA, 1998[1]; ASTM, 2004[2]). The primary line of evidence is plume status, which includes the stability of the plume, the transport behavior of the contaminants, and evidence of the production of intermediates or products of biological degradation. This primary evidence can include the attenuation of concentrations in groundwater over time or distance at the site. For example, a static or shrinking plume provides clear evidence of natural attenuation. An expanding plume can still indicate natural attenuation is occurring just not at a rate sufficient counteract the rate of migration in groundwater. The secondary lines of evidence include the behavior of geochemical parameters, which indicate that conditions conducive to biological degradation exist in the environment and are indicators of naturally occurring biological degradation, and natural attenuation rates based on temporal or spatial trends. In general, electron acceptors will be depleted sequentially through the plume (oxygen followed by nitrate, followed by ferric iron, etc.) with the formation of products (carbon dioxide, ferrous iron, methane, etc.). Additional lines of evidence can include transport modeling, estimates of assimilative capacity, and laboratory studies.

The following sections present the lines of evidence for natural biological degradation at the Site. The groundwater data used in this evaluation include data collected through October 2009 and are provided in Attachment A.

---

[1] United States Environmental Protection Agency. 1998. Technical Protocol for Evaluating Attenuation of Chlorinated Solvents in Ground Water. EPA/600/R-98/128.

[2] ASTM. 2004. Standard Guide for Remediation of Groundwater by Natural Attenuation at Petroleum Release Sites. E1943-98 (Re-approved 2004).

2.0 PRIMARY LINES OF EVIDENCE FOR NATURAL ATTENUATION

The status of the BEX plume at the Site has been established through groundwater monitoring data using the Mann-Kendall statistical test for trend and the detection of methane as a product of BEX degradation.

2.1 MANN-KENDALL STATISTICAL TEST FOR TREND

The Mann-Kendall statistical test for trend was used to establish the stability of the concentrations trends over time. The Mann-Kendall test is a non-parametric test that can be used to assess whether concentrations exhibit increasing or decreasing trends over time to a specified level of confidence.

This analysis requires a minimum of four sampling events and was performed on data from monitoring wells MW-2, MW-3, MW-11, MW-14, MW-15, MW-22, and RW-1 for the time period 2001 through October 2009. Monitoring wells MW-101 through MW-112 have only been sampled one or two times prior to the pilot testing and were not evaluated. Only data through the pilot test baseline sampling event in April 2009 at monitoring well MW-19, which was within the pilot test area, were evaluated.

Using data collected since 2001, trends were evaluated for:

- Benzene at MW-3, MW-11, MW-14, MW-15, MW-19, MW22
- Ethylbenzene at MW-2, MW-3, MW-15, MW-19, MW-22, RW-1
- Xylenes at MW-2, MW-3, MW-19, MW-22, and RW-1

Concentrations of other BEX constituents at these wells were either at or below the detection limit at the majority of sampling events and were not evaluated.

Values below the detection limits were entered as the detection limit selecting one detection limit per data set to avoid “trending the detection limits”. The results are provided as “Increasing”, “Decreasing”, or “No Trend” at 80% or 90% confidence level, as summarized below in Table 1. The statistical tables are provided in Attachment B.

Table 1Mann-Kendall Trend Analyses Summary

Well	Benzene	Ethylbenzene	Xylenes
MW-2	na	Decreasing /80%	Decreasing /80%

MW-3	Decreasing /90%	Decreasing /90%	Decreasing /90%
MW-11	No Trend/Stable	na	na
MW-14	No Trend/Nonstable	na	na
MW-15	No Trend/Stable	No Trend/Nonstable	na
MW-19	Decreasing/80%	No Trend / Stable	No Trend/ Stable
MW-22	Decreasing/80%	No Trend/Stable	No Trend/Stable
RW-1	na	No Trend/Stable	No Trend/Stable

na = not evaluated

At all evaluated wells, the concentrations of the constituents are either decreasing or stable. These results indicate that the plume to the north of Molloy Road is a stable plume that has begun to shrink in some areas (e.g. the vicinity of MW-2, MW-3 MW-19 and MW-22). Soil removal actions that were conducted in August 2008 would have reduced the flux of constituents into groundwater and may have contributed to plume stabilization.

Data from the three sampling events at wells MW-101, MW-105, and MW-107, which could not be evaluated statistically using the Mann-Kendall test, also showed evidence of decreasing concentrations between November 2006 and April 2009 prior to the pilot test.

2.2 *DETECTION OF BIOLOGICAL DEGRADATION PRODUCTS*

Intermediates of BEX biodegradation are generally not detected in plumes. However, one of the end-products of anaerobic biodegradation methane can be detected. Only at monitoring wells at which BEX has been detected at greater than 10 micrograms per liter (µg/L) has methane been detected at 1 milligram per liter (g/L) or higher at one or more sampling events. Methane has only been detected at 0.05 mg/L or less at the majority of wells at which BEX has never been detected. These data indicate that methane is being produced as a product of BEX biodegradation.

3.0 SECONDARY LINES OF EVIDENCE FOR NATURAL ATTENUATION

3.1 GEOCHEMICAL PARAMETER DATA

Geochemical parameters included the redox sensitive parameters presented in Table B-1. These parameters include:

- ORP, which is a measure of the oxidizing or reducing conditions that can affect biological degradation within the aquifer
- Dissolved oxygen is the aerobic electron acceptor that can support the aerobic degradation processes
- Nitrate and sulfate are anaerobic electron acceptors that can support anaerobic degradation processes
- Ferrous iron is the product of the use of iron as an anaerobic electron acceptor
- Methane is the product of methanogenesis, which is a strictly anaerobic biological process through which biodegradation can occur
- Alkalinity/total hardness
- pH is a measure of whether conditions are acidic or basic; most biological processes are generally most active in the range of 6 to 8; some biological processes can affect pH.

These geochemical parameters were measured at six sampling events between 2001 and 2009. Table B-1 presents these results. The field parameters of dissolved oxygen, ORP, and pH were measured at all wells and have been measured historically at the site.

ORP values at the February 2008 sampling event ranged from -248 millivolts (mV) at RW-1 (strongly reducing) to 207 mV at MW-20 (strongly oxidizing). Positive ORP values were observed at 19 of the 22 wells at which all VOCs were below the detection limit, while negative values were observed at five of the six well with VOC detections. At the October 2009 sampling event, ORP values ranged from -163 mV at MW-11 to 59 mV at MW-109 and were positive at about half of the wells at which all VOCs were below the detection limit. Negative values were observed at six out of the ten wells with VOC detections. These observations are consistent with the generation of reducing conditions within the hydrocarbon plume due to biological degradation. These data indicate that conditions within the dissolved plume are generally anaerobic.

Dissolved oxygen concentrations at the February 2008 sampling event ranged from 0.13 to 0.88 mg/L at the six wells at which VOCs were detected and from 0.16 to greater than 7 mg/L at wells at which VOCs were not detected, Dissolved oxygen concentrations greater than 2 mg/L were detected at eight of the wells without VOC detections. At the October 2008 sampling event, dissolved oxygen concentrations were less than 1 mg/L at all but two wells, both of which had no detected VOCs. These data indicate that groundwater at the Site is generally aerobic outside of the plume and anoxic within the plume. These observations are consistent with the depletion of oxygen as an electron acceptor to support hydrocarbon degradation.

Nitrate has historically been detected at very low concentrations ranging from less the detection limit (<0.1 mg/L) to 3.3 mg/L. These low concentrations indicate that nitrate is not a significant electron acceptor for hydrocarbon degradation at the site.

Sulfate has historically been detected at concentrations ranging between 2.4 and 99 mg/L and ranged between 3.4 and 99 mg/L at the February 2008 sampling event and <0.1 to 63 mg/L at the October 2009 sampling event. [Sulfate was reported twice at concentrations outside this range in November 2006 at 170 and 240 mg/L at RW-1 and MW-20, respectively; however, these results were inconsistent with other reported concentrations at these wells.] Higher concentrations (41 to 70 mg/L) were generally observed at wells on the northeastern boundary of the plume (MW108, MW-102, MW-109, MW-16, MW-104, MW-110 and MW-11) than on the northwestern side of the plume (MW-5, MW-18, MW-4, and MW-20) with concentrations ranging from 6 to 11 mg/L. In the downgradient portion of the plume south of Molloy Road, the highest concentrations were observed outside of the plume at wells MW-103, MW-104, MW-106, MW-100 and MW-111 with concentrations ranging from 36 to 65 mg/L, while the lowest concentrations were observed at wells MW-105 and MW-112 within the plume at 5.6 and 19 mg/L. These data indicate the consumption of sulfate as an electron acceptor and is consistent with degradation of BEX under sulfate-reducing conditions.

Ferrous Iron, the product of iron reduction, has historically been detected at concentrations ranging from below the detection limit to 6.1 mg/L. At upgradient wells MW-5 and MW-18, ferrous iron has only been detected once at 0.3 mg/L, while concentrations of 0.4 to 1.6 mg/L have been detected at upgradient wells MW-102 and MW-108. The highest concentrations of ferrous iron have historically been detected generally at wells with elevated BEX concentrations such as MW-2, MW-3, and MW-15. These data indicate that biological degradation of BEX through iron reduction is occurring within the plume.

Methane, the product of anaerobic methanogenesis, has only been detected at trace amounts upgradient wells MW-5 MW-18, MW-102 and MW-108. Methane has only been detected at 0.05 mg/L or less at the majority of wells at which BEX has never been detected. Only at monitoring wells at which BEX has been detected at greater than 10 micrograms per liter (µg/L) has methane been detected at 1 to 7.8 mg/L at one or more sampling events. These data indicate that methane is being produced as a product of BEX biodegradation.

The ***pH values*** ranged between 6.3 and 8.3, with the exception of the November 2006 sampling event, when values less than 5 were observed at several wells. The range of 6.3 to 8.3 is generally within the neutral range that is conducive to most biological processes.

Overall, the geochemical parameter data indicate that conditions within the plume are anoxic and reducing with depletion of oxygen and sulfate and the production of ferrous iron and methane. The depletion of oxygen and sulfate and the production of methane, and ferrous iron confirm that both aerobic and anaerobic biological processes are occurring at the site and provide supportive evidence that the attenuation of BEX is occurring through multiple biological degradation pathways.

3.1.1 Natural attenuation rates based on temporal trends

Concentration trends over time can be used to assess rates of natural attenuation. The rate includes all mechanisms of attenuation including biological degradation and physical processes such as volatilization.

Apparent natural attenuation rates were estimated using time-series data and assuming a first order decay of concentration over time:

$$C_t = C_0 * e^{-kt}$$

where:

C_0 = initial concentration
C_t = concentration at time t in years
t = time in years
k = apparent first order rate constant ($year^{-1}$)

To estimate k from time-series data, this equation was rearranged to:

$$\ln(C_t/C_0) = -kt$$

where k is the slope of the line defined by $\ln(C_t/C_0)$ versus t and was determined using linear regression techniques. An apparent half-life ($t_{1/2}$) was than calculated using:

$$t_{1/2} = -\ln(0.5)/k$$

where $t_{1/2}$ is the time at which C_t will equal 0.5 x C_0.

These rate constants were calculated from time-trend concentration data from MW-2 and MW-3, the two wells at which statistically decreasing trends have been observed. The rate calculations from time trend data are presented in Attachment C and summarized in Table 2.

Table 2Rate Constants from time trend data

Well	Benzene	Ethylbenzene	Xylenes
MW-2	na	0.27	0.35
MW-3	1.25	1.11	0.85

na = not evaluated

These rate constants are within the lower range of rate constants observed at other sites.

3.1.2 Natural attenuation rates based on spatial trends

The change in concentration with stance through a plume can be used to assess the rate of attenuation. However, concentrations with distance through the plume at the site fluctuate with distance and do not provide consistent spatial trends to assess attenuation rates.

3.1.3 Assimilative capacity for BEX

The amount of biological degradation that can be supported by an aquifer is called the assimilative capacity. The assimilative capacity (in mg/L) is measured by the availability of electron acceptors including dissolved oxygen, nitrate, sulfate, iron (as measured indirectly by the formation of ferrous iron) and the estimated capacity for methanogenesis (as measured by the production of methane). By convention, the amount of available electron acceptor is determined as the difference (delta) between the concentration in background wells and the downgradient portion of the plume. For background concentrations, the averages of the electron acceptor/product concentrations at wells MW-5, MW-18, MW-102, and MW-108 from the February 2008 sampling event were used. For the downgradient plume concentrations, the averages of the electron acceptor/product concentrations at wells RW-1, MW-105, and MW112 from the February 2008 sampling event were used.

A utilization factor based on the stoichiometry of BEX degradation is then used to convert the amount of electron acceptor to the assimilative capacity for a given contaminant. The utilization factors and the assimilative capacity calculations are presented below in Table 3. Based on this calculation, the aquifer has the capacity to degrade at least 106 mg/L hydrocarbons.

The major Terminal Electron Acceptor Process (TEAP) across the plume is sulfate reduction with iron reduction as the secondary TEAP.

Table 3 Assimilative capacity for BEX

Electron Acceptor	Unit	Bkgrd	Plume	Delta	Utilization Factor	Assimilative Capacity
Dissolved oxygen	mg/L	2.4675	0.31	2.16	3.14	6.77
Nitrate	mg/L	0.6575	0.16	0.50	4.9	2.44
Iron	mg/L	0.5	1.23	0.73	21.8	15.99
Sulfate	mg/L	26.75	10.43	16.32	4.7	76.69
Methane	mg/L	0.0055	6.47	6.46	0.78	5.04
					TOTAL	106.93

4.0 BIOREMEDIATION PILOT TEST

The biodegradation of BEX is occurring under natural attenuation conditions; however, this intrinsic rate has historically been insufficient to contain the plume on Site. In 2009, ERM conducted a pilot test (PT) southwest of the RamTech facility, west of along Fairway Drive, north and south Molloy Road to evaluate the effectiveness of enhanced natural attenuation using a calcium perioxide (CaO_2) slurry to deliver oxygen. The goal of the PT was to decrease the concentrations of BEX in groundwater, and to prevent further migration of the BEX plume onto off-site property.

The baseline sampling of selected monitoring wells adjacent and down-gradient of the PT was conducted on 13 April 2009. The following monitoring wells were sampled: Monitoring Well MW-19, MW-105, MW-106, MW-107, MW-111 and MW-112. The wells were sampled in general conformance with USEPA low-flow (minimal drawdown) well purging and sample collection techniques (USEPA 1996). In addition, during the "baseline" groundwater sampling event, all monitoring wells were analyzed for natural attenuation parameters to evaluate the performance of the PT.

The CaO_2 slurry was injected into the saturated zone through 20 injection points within the BEX plume during the PT. The introduction of CaO_2 provides a controlled release of oxygen which permeates throughout the substrate enhancing microbial activity which biodegrade BEX compounds. Further details on the PT are provided in the Technical Memorandum entitled *Site 15 Interim Remedial Action Supplemental Remedial Investigation/Focused Feasibility Study Draft Technical Memorandum,* 174th Fighter Wing - New York Air National Guard- Hancock Air National Guard Base – Syracuse, New York – ERM, Dewitt, New York, November 2009.

Following injection, the eight PT monitoring wells were resampled on 5 August 2009 and during the week of 5 October 2009. These analytical data are summarized along with historical data in Attachment A.

BEX compounds were not detected in five of the eight groundwater samples (MW-106, MW-107, MW-112, MW-113, and MW-114) at either the baseline sampling event or the two subsequent events. Review of these data indicates that the injection of CaO2 slurry, in general, enhanced the natural attenuation process.

Concentrations of ethylbenzene and xylenes decreased to below the NYSDEC ambient groundwater quality standards in MW-105 by the August sampling event and still remained over 10-fold lower in October 2009 than the concentrations at the baseline sampling event prior to the PT injection. At MW-112, concentrations of ethylbenzene and xylene were over six-fold in October than at the baseline sampling event. Benzene concentrations, although slightly higher than at the baseline sampling event, remained below historical concentrations at both wells.

Concentrations of BEX at MW-19, which had been at historically low concentrations in February 2009 and at the baseline sampling event, showed increases at the August and October 2009 sampling events. These observations may be due to the August 2009 excavation activities, which may have resulted in the release of some BEX mass to groundwater. The oxygen that was delivered during the pilot test may have been insufficient to attenuate this mass. Comparison of the concentration data between August and October indicate a decreasing trend.

The overall conclusions are that the injection of CaO_2 slurry enhanced natural attenuation within the plume, that the loading of CaO_2 slurry was sufficient in the downgradient portion of plume, but that the loading of CaO_2 slurry was insufficient near Molloy Road to significantly decrease the mass flux closer to the former source area.

5.0 CONCLUSIONS

Natural attenuation of BEX is occurring at the site through both aerobic and anaerobic biological processes. This evaluation indicates that the naturally occurring microbial population is capable of degrading these constituents using all available electron acceptors. However, while sufficient electron acceptors appear to be available to completely attenuate the plume, the rate at which attenuation is occurring has been insufficient to contain the plume on site. The rate has also been insufficient to result in decreasing concentrations across the plume. Concentrations are decreasing in the vicinity of MW-2 and MW-3; however, the soil removal actions may have contributed to these reductions. Concentrations appear to be still increasing in the vicinity of RW-1.

The major TEAPs within the plume are anaerobic processes – sulfate reduction and iron reduction. These processes are generally significantly slower than aerobic degradation, which utilizes oxygen as the terminal electron acceptor. Although oxygen is present and is responsible for some of the naturally occurring degradation, it is not responsible for the majority of the degradation.

Natural attenuation of BEX in groundwater is occurring in Site 15 groundwater. However, the rate of natural attenuation is not sufficient to prevent additional migration of BEX in groundwater as evidenced by continued expansion of the dissolved-phase BEX plume.

Injection of CaO_2 slurry during the PT delivered oxygen and enhanced natural attenuation within the plume with the result that concentrations in the down gradient portion of the plume were substantially reduced.

Based on the natural attenuation evaluation and the PT, the addition of oxygen to stimulate aerobic degradation is likely to be an effective process for stimulating the rate of biodegradation of the residual constituents in groundwater.

Attachment A
Summary of Groundwater Analytical Data

Attachment A
Summary of Groundwater Analytical Data-2001through 2008
Site 15-174th Fighter Wing Air National Guard
Hancock Field, Syracuse, NY
ERM Project Number 0086335

WELL ID	**MW-2**							**MW-3**					**MW-4**					
Sample Date	**Jan-01**	**Oct-01**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Jan-01**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**
VOCs (ug/l)																		
BENZENE	<1	<2	<1	<1	<2	<1	<1	**200**	**57**	**75**	<1	<1	<1	<1	<1	<1	<1	<1
ETHYL BENZENE	**320**	**180**	3.5	**83**	**52**	<1	**200**	**200**	**16**	**61**	<1	<1	<1	<1	<1	<1	<1	<1
TOLUENE	<1	<2	<1	<1	<2	<1	NA	<1	<1	0.34J	<1	NA	<1	<1	<1	<1	<1	NA
XYLENE	**900**	**340**	2	**98**	**44**	<1	**370**	**95**	**15**	**28**	<1	<2	0.6 J	<1	<1	<1	<1	<2
MTBE	na	na	<1	<1	<2	<1	NA	<1	<1	<2	<1	NA	na	<1	<1	<1	<1	NA
NATURAL ATTENUATION PARAMETERS (mg/l)																		
NITRATE	0.50	na	0.55	<0.1	0.17	0.86	< 0.1	0.21	<0.1	----	0.33	< 0.1	0.20	0.13	0.41	----	0.18	0.21
SULFATE	3.0	na	67.0	7.5	37	98	3	2.8	2.4	4	6.0	9.3	49.0	26.0	26.0	8.9	3.7	37.0
ALKALINITY	na	na	300	310	380	190	400	270	350	300	120	360	na	190	250	240	40	290
TOTAL HARDNESS	na	na	740	310	350	820	590	380	310	230	57	500	na	240	250	180	37	350
AMMONIA	na	na	<0.03	0.088	UJ	0.046	0.2	<0.03	0.76	0.065J	<0.03	0.75	na	<0.03	0.18	----	<0.03	0.11
METHANE	9.000	na	<0.005	8.800	----	0.0076	4.4	0.100	1.600	----	<0.0021	0.28	0.100	0.011	0.011	----	<0.0021	0.012
PARAMETERS MEASURED IN THE FIELD																		
FERROUS IRON	5.4	na	0.0	3.8	0.9	0.8	4.2	6.1	3.3	2.2	0	2.1	1.2	----	1.200	0	0	1
pH	7.5	na	7.06	6.95	8.26	6.96	7.54	6.92	6.45	6.77	6.3	6.33	6.92	7.30	6.88	8.26	7.16	7.43
DISSOLVED OXYGEN	0.06	na	0.00	0.00	0.29	2.28	0.18	0.00	0.00	2.79	7.99	0.12	10.44	1.15	0.00	0	0.64	0.49
OXIDATION REDUCTION POTENTIAL	-80	na	76	-127	-76	123.9	44.4	-61	-81	-8	146.6	-71	9	43	-113	-46	186.9	44
CONDUCTIVITY	0.810	na	1.120	0.999	1.4	6.794	1.471	0.531	0.811	0.76	0.106	0.822	0.670	0.366	0.803	0.391	0.067	0.440
FIELD OBSERVATIONS	na	na	----	----	----	----	---	Odor	Odor	Odor	----	---	na	----	----	----	----	---

Attachment A
Summary of Groundwater Analytical Data-2001through 2008
Site 15-174th Fighter Wing Air National Guard
Hancock Field, Syracuse, NY
ERM Project Number 0086335

WELL ID	**MW-5**					**MW-8**						**MW-9**						
Sample Date	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Jan-01**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Jan-01**	**Oct-01**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**
VOCs (ug/l)																		
BENZENE	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	3	<1	<1	<1	<1	<1
ETHYL BENZENE	<1	<1	<1	<1	<1	<1	**6.4**	<1	<1	<1	<1	<1	<10	<1	<1	<1	<1	<1
TOLUENE	<1	<1	<1	<1	NA	<1	<1	<1	<1	<1	NA	<1	<10	<1	<1	<1	<1	NA
XYLENE	<1	<1	<1	<1	<2	<1	4	<1	<1	<1	<2	<1	<10	<1	<1	<1	<1	<2
MTBE	<1	<1	<1	<1	NA	<1	<1	<1	<1	<1	NA	na	na	<1	<1	<1	<1	NA
NATURAL ATTENUATION PARAMETERS (mg/l)																		
NITRATE	1.20	0.98	0.28	1.3	< 0.1	0.30	0.20	<0.1	----	1.2	< 0.1	2.60	na	0.16	0.37	0.1	0.91	< 0.1
SULFATE	12.0	15.0	11	8.0	8.6	33.0	24	28	42	8.7	52.0	54.0	na	38.0	21.0	20	6.1	12.0
ALKALINITY	220	260	340	140	280	na	320	320	250	88	400	na	na	110	200	270	32	260
TOTAL HARDNESS	280	260	270	180	310	na	380	120	370	96	650	na	na	130	360	83	26	220
AMMONIA	<0.03	<0.03	UJ	<0.03	<0.03	na	<0.03	<0.03	UJ	<0.03	< 0.03	na	na	<0.03	0.25	0.12J	0.14	0.37
METHANE	----	----	----	<0.0021	0.02	0.020	0.730	0.015	----	0.0024	0.011	<0.002	na	----	0.020	----	<0.0021	----
PARAMETERS MEASURED IN THE FIELD																		
FERROUS IRON	----	0.300	0	0	1.7	0.6	2.0	2.4	1	0.8	1.2	0.2	na	0.1	2.0	1.05	1.1	2
pH	7.12	8.21	6.68	7.04	7.14	6.70	6.94	7.12	4.58	6.29	7.7	6.48	na	6.27	6.51	6.41	6.64	8.31
DISSOLVED OXYGEN	4.80	0.00	0.77	7.70	0.00	8.38	0.00	0.00	10.9	6.21	0.35	0.39	na	0.00	0.00	0	10.09	3.02
OXIDATION REDUCTION POTENTIAL	146	-50	121	41.6	-109	45	-28	-126	271	41	12.8	96	na	152	-26	0.43	109.9	-144.7
CONDUCTIVITY	0.391	0.362	0.577	0.377	0.595	0.940	0.706	0.999	0	0.172	0.873	6.280	na	1.270	0.969	0.83	0.137	1.006
FIELD OBSERVATIONS	----	----	----	----	---	na	----	----	----	----	----		na	Odor	Odor	----	----	----

Sheen= Sheen on purge water and/or sample

Attachment A
Summary of Groundwater Analytical Data-2001through 2008
Site 15-174th Fighter Wing Air National Guard
Hancock Field, Syracuse, NY
ERM Project Number 0086335

WELL ID	**MW-11**							**MW-14**							**MW-15**						
Sample Date	**Jan-01**	**Oct-01**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Jan-01**	**Oct-01**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Jan-01**	**Oct-01**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**
VOCs (ug/l)																					
BENZENE	<1	**18**	**32**	**31**	**17**	< 1	**49**	<1	**14**	**3.7**	**4.5**	**2**	< 1	**3.9**	<1	**150**	**100**	**140**	**66**	**6.8**	**10**
ETHYL BENZENE	<1	3	<1	1.4	0.63J	< 1	**11**	<1	5	<1	1.2	0.22J	< 1	<1	<1	**92**	**28**	**33**	**38**	<2	**11**
TOLUENE	<1	2	<1	<1	0.11J	< 1	NA	<1	<2	<1	<1	<1	< 1	NA	<1	<2	<1	<2	<2	<2	NA
XYLENE	<1	<2	<1	**5.2**	0.36J	< 1	**16**	<1	2	<1	<1	<1	< 1	<2	<1	82	3	<2	<2	<2	<2
MTBE	na	na	<1	2.2	<1	< 1	NA	na	na	<1	1.9	<1	< 1	NA	na	na	<1	2.8	<2	<2	NA
NATURAL ATTENUATION PARAMETERS (mg/l)																					
NITRATE	0.20	na	0.23	0.15	----	0.34	<0.1	<0.1	na	0.77	<0.1	----	0.26	<0.1	<0.1	na	0.21	<0.1	----	0.8	<0.1
SULFATE	27.0	na	8.8	22.0	22	72	5	45.0	na	24	43	45	66.0	45.0	33.0	na	37	17	27	28	31
ALKALINITY	na	na	330	330	260	370	360	na	na	230	320	370	350	340	na	na	380	340	290	410	340
TOTAL HARDNESS	na	na	320	320	370	440	510	na	na	230	350	380	400	470	na	na	430	370	380	460	420
AMMONIA	na	na	<0.03	<0.03	0.042J	<0.03	<0.03	na	na	<0.03	<0.03	0.2	<0.03	<0.03	na	na	<0.03	<0.03	0.11J	0.041	<0.03
METHANE	0.080	na	0.006	0.740	----	0.052	1.6	0.020	na	1.800	0.130	0.039	0.14	0.16	0.020	na	2.100	1.400	----	0.93	0.19
PARAMETERS MEASURED IN THE FIELD																					
FERROUS IRON	3.2	na	4.0	4.4	1.6	2.5	2.2	5.6	na	0.5	2.8	NM	1.4	2	4.2	na	4.6	3.1	2.95	2.2	2.4
pH	7.16	na	7.38	7.19	4.51	7.29	7	7.57	na	6.96	7.07	7.33	7.13	7.68	7.06	na	7.00	6.88	7.2	7.16	7.55
DISSOLVED OXYGEN	10.07	na	0.00	0.00	11.36	0.23	0.00	0.00	na	2.12	0.00	0	0.20	0.15	10.93	na	0.00	0.00	0	0.31	0.13
OXIDATION REDUCTION POTENTIAL	96	na	-271	-155	270	-93.1	-163	-28	na	-14	-137	-121	-50.2	14.7	-98	na	-67	150	-153	-99.1	7.8
CONDUCTIVITY	1.080	na	0.643	0.97	0	1.056	1.280	0.780	na	0.496	0.9	0.91	0.567	0.467	0.850	na	1.170	1.01	0.99	0.630	525.000
FIELD OBSERVATIONS	na	na	Odor	Odor	----	----	Odor	na	na	Odor	Odor	Odor	Dye Visible	Dye Visible	na	na	----	----	Odor	----	Odor

Sheen= Sheen on purge water and/or sample

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WELL ID	**MW-16**						**MW-17**						**MW-18**					
Sample Date	**Jan-01**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Jan-01**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Jan-01**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**
VOCs (ug/l)																		
BENZENE	<1	<1	<1	<2	< 1	<1	<1	<1	<1	0.18J	< 1	<1	<1	<1	<1	<1	< 1	<1
ETHYL BENZENE	1.5	<1	<1	0.25J	< 1	<1	1.4	<1	2	**49**	< 1	<1	<1	<1	<1	<1	< 1	<1
TOLUENE	**5.5**	<1	<1	<2	< 1	NA	<1	<1	<1	<1	< 1	NA	<1	<1	<1	<1	< 1	NA
XYLENE	<1	<1	<1	0.38J	< 1	<2	<1	<1	<1	**31**	< 1	<2	<1	<1	<1	<1	< 1	<2
MTBE	na	<1	<1	<2	< 1	NA	na	<1	<1	<1	< 1	NA	na	<1	<1	<1	< 1	NA
NATURAL ATTENUATION PARAMETERS (mg/l)																		
NITRATE	<0.1	0.20	<0.1	0.11	0.48	<0.1	<0.1	3.20	0.13	----	3.3	<0.1	0.80	1.40	0.34	0.83	0.52	<0.1
SULFATE	38.0	62	37	99	63	63	38.0	58	16	41	27	19	38	13	12	13	6.0	14.0
ALKALINITY	na	260	350	520	400	370	na	260	360	320	260	370	na	290	310	320	92	390
TOTAL HARDNESS	na	450	390	480	530	550	na	300	370	370	260	540	na	300	280	300	99	430
AMMONIA	na	<0.03	<0.03	5.1J	<0.03	<0.03	na	1.50	1.2	0.13J	<0.03	0.22	na	<0.03	<0.03	UJ	<0.03	<0.03
METHANE	0.080	----	0.057	0.0078	<0.0021	0.0089	0.600	0.033	1.4	----	<0.0021	1.1	<0.002	----	----	----	<0.0021	0.0029
PARAMETERS MEASURED IN THE FIELD																		
FERROUS IRON	0.0	----	0.4	NM	0.2	0.2	3.400	----	2.2	3.2	0	1.4	<0.05	----	0.000	0	0	0
pH	6.70	7.17	6.99	7.15	6.67	7.6	6.89	7.35	6.83	7.01	6.75	6.69	7.57	7.25	8.10	7.13	7.07	7.49
DISSOLVED OXYGEN	9.91	1.70	0.00	0	1.30	0.42	9.02	0.00	0.00	0	6.29	0.00	1.11	0.20	0.00	0	1.06	1.11
OXIDATION REDUCTION POTENTIAL	103	-85	-16	-19	153.8	18.9	-39	-308	-139	-98	53.9	-115	293	-202	127	185	181.1	44.5
CONDUCTIVITY	1.000	1.050	0.97	3.06	1.052	0.891	0.860	0.623	0.6	0.9	0.522	1.260	0.790	0.486	0.378	0.986	0.143	0.568
FIELD OBSERVATIONS	na	----	----	----	Dye Visible	Dye Visible	na	----	----	----	----	----	na	----	----	----	----	----

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WELL ID	**MW-19**									**MW-20**							**MW-22**					
Sample Date	**Jan-01**	**Oct-01**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Jan-01**	**Oct-01**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Oct-01**	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**
VOCs (ug/l)																						
BENZENE	**11**	**23**	**28**	**33**	**17J**	<2	0.71 J	**6**	**< 10**	<1	<2	<1	<1	<1	< 1	<1	**22**	**110**	**70**	**51**	< 1	**5.6**
ETHYL BENZENE	**82**	**450**	**300**	**610**	**270**	**8.5**	**17**	**410**	**380**	<1	<2	<1	<1	<1	< 1	<1	**14**	**89**	**32**	**82**	< 1	**21**
TOLUENE	<1	<2	<5	<10	<20	<2	NA	NA	NA	<1	2	<1	<1	<1	< 1	NA	<2	<2	<1	0.34J	< 1	NA
XYLENE	**16**	**440**	**650**	**860**	**460**	**9**	**20**	**760**	**420**	<1	<2	<1	<1	<1	< 1	<2	**32**	**88**	**46**	**90**	< 1	3
MTBE	na	na	<5	<10	<20	<2	NA	NA	NA	na	na	<1	<1	<1	< 1	NA	na	<2	<1	<2	< 1	NA
NATURAL ATTENUATION PARAMETERS (mg/l)																						
NITRATE	0.20	na	0.19	<0.1	----	0.28	----	----	<0.1	0.20	na	0.45	<0.1	<0.1	1.4	<0.1	na	1.50	<0.1	0.3	1.9	<0.1
SULFATE	8.0	na	15.0	<1	11	25.0	20.0	6.7	4.9	10	na	36	15	240	11.0	9.4	na	32.0	8.8	41	16.0	31.0
ALKALINITY	na	na	350	330	240	410	330	330	340	na	na	340	340	370	67	350	na	330	400	370	170	410
TOTAL HARDNESS	na	na	340	350	330	350	400	560	550	na	na	420	330	300	83	330	na	390	340	340	160	570
AMMONIA	na	na	<0.03	<0.03	0.75J	<0.03	----	0.077	0.16	na	na	<0.03	<0.03	0.03J	<0.03	< 0.03	na	<0.03	0.12	0.1	<0.03	<0.03
METHANE	1.000	na	3.4	3.5	----	0.99	0.61	0.98	3	0.030	na	0.018	0.027	----	<0.0021	0.13	na	2.300	1.800	1.3	0.017	1
PARAMETERS MEASURED IN THE FIELD																						
FERROUS IRON	5.6	na	----	4.1	2.2	2	1.7	2.7	1.9	5.6	na	----	2.500	1.2	0	1.8	na	----	5.300	NM	0	0.8
pH	6.71	na	6.78	6.68	4.66	6.37	7.1	6.64	8.21	7.20	na	7.06	6.71	4.69	6.47	7.48	na	6.87	7.81	5.19	6.57	6.85
DISSOLVED OXYGEN	8.02	na	0.00	0.00	10.95	0.88	0.71	0.29	0.21	0.00	na	0.00	0.00	11.17	0.26	0.23	na	5.70	0.00	9.55	0.16	0.00
OXIDATION REDUCTION POTENTIAL	-51	na	-79	-101	267	23.7	11.6	-33.4	-132.6	-23	na	-390	-76	261	207.5	-50.1	na	-242	-92	226	174.9	-25
CONDUCTIVITY	2.040	na	1.210	0.91	0	1.260	0.997	1.052	1.450	0.920	na	0.839	0.954	0	0.143	0.807	na	0.607	1.07	0	0.155	1.410
FIELD OBSERVATIONS	na	na	----	----	----	----	----	Odor	----	na	na	----	----	----	----	----	na	Odor	Odor	----	Odor	----

Sheen= Sheen on purge water and/or sample

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WELL ID	**RW-1**					**MW-101**			**MW-102**			**MW-103**			**MW-104**		
Sample Date	**Apr-05**	**Sep-05**	**Nov-06**	**Feb-08**	**Oct-09**	**Nov-06**	**Feb-08**	**Oct-09**	**Nov-06**	**Feb-08**	**Oct-09**	**Nov-06**	**Feb-08**	**Oct-09**	**Nov-06**	**Feb-08**	**Oct-09**
VOCs (ug/l)																	
BENZENE	<1	**2.4**	**1.4J**	**<2**	<1	**8.9**	<5	<1	<1	< 1	<1	<1	< 1	**1.3**	<1	< 1	<1
ETHYL BENZENE	**11.0**	**18**	**60**	**45**	<1	**110**	**22**	**7.9**	<1	< 1	<1	<1	< 1	<1	<1	< 1	<1
TOLUENE	<1	<1	0.4J	<2	NA	<5	<5	NA	<1	< 1	NA	<1	< 1	NA	<1	< 1	NA
XYLENE	**21.0**	**36.0**	**30**	**60**	<2	**230**	**41**	**7.4**	<1	< 1	<2	<1	< 1	<1	<1	< 1	<1
MTBE	<1	<1	<1	<2	NA	<5	<5	NA	<1	< 1	NA	<1	< 1	NA	<1	< 1	NA
NATURAL ATTENUATION PARAMETERS (mg/l)																	
NITRATE	0.12	<0.1	----	0.18	<0.1	0.72	0.47	<0.1	0.13	0.42	<0.1	0.34	0.32	<0.1	0.38	0.3	<0.1
SULFATE	13.0	19.0	170	6.7	5	44	35	42	50	52	5	27	36	33	39	4.5	41
ALKALINITY	200	310	310	250	310	380	300	360	410	390	340	250	340	330	330	54	370
TOTAL HARDNESS	240.0	310.0	380	280	430	430	420	490	550	520	640	310	360	510	440	22	500
AMMONIA	0.45	0.34	1.1	0.44	0.82	0.12	<0.03	<0.03	UJ	<0.03	<0.03	----	<0.03	<0.03	0.13	0.34	<0.03
METHANE	1.300	1.300	6.3	4.4	1.3	0.63	0.55	0.44	0.026	0.016	0.0084	0.27	0.90	0.10	0.055	<0.0021	0.033
PARAMETERS MEASURED IN THE FIELD																	
FERROUS IRON	1.0	3.2	NM	1.3	2.5	2.8	1.6	1.2	0.6	0.4	1.8	1.2	0.9	2.9	0.2	0.0	2.1
pH	7.11	7.01	6.8	6.90	6.83	5.15	7.82	6.98	4.89	6.93	7.40	4.65	7.12	6.82	7.27	6.99	7.55
DISSOLVED OXYGEN	0.00	0.00	0	0.13	0.00	9.84	0.50	0.00	9.9	0.72	0.16	10.92	0.33	0.00	0	12.38	0.28
OXIDATION REDUCTION POTENTIAL	-129	-166	-200	-248.8	-156	238	-35.2	-103	267	46.3	46.8	275	-48.9	-132	-51	112.3	-70.5
CONDUCTIVITY	0.605	0.999	12.1	0.666	1.100	0	0.731	1.280	0	1.459	1.532	0	1.776	1.420	1.49	0.034	1.674
FIELD OBSERVATIONS	Odor/ Sheen	Odor	Odor	Odor/sheen	ve Visible/ Oc	Odor/sheen	----	----	----	----	----	----	----	----	----	----	----

Sheen= Sheen on purge water and/or sample

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WELL ID	**MW-105**					**MW-106**					**MW-107**					**MW-108**	
Sample Date	**Nov-06**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Nov-06**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Nov-06**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Feb-08**	**Oct-09**
VOCs (ug/l)																	
BENZENE	**110**	**86**	**6.2**	**3.3**	**16**	<1	< 1	< 1	< 1	<1	0.52J	< 1	< 1	< 1	<1	< 1	<1
ETHYL BENZENE	**300**	**260**	**120**	<1	**8.6**	<1	< 1	< 1	< 1	<1	**30**	< 1	< 1	< 1	<1	< 1	<1
TOLUENE	<20	<20	NA	NA	NA	<1	< 1	NA	NA	NA	<1	< 1	NA	NA	NA	< 1	NA
XYLENE	**480**	**430**	**260**	<2	**14**	<1	< 1	<2	<2	<2	0.41J	< 1	0.27 J	<2	<2	< 1	<2
MTBE	<20	<20	NA	NA	NA	0.34J	< 1	NA	NA	NA	<1	< 1	NA	NA	NA	< 1	NA
NATURAL ATTENUATION PARAMETERS (mg/l)																	
NITRATE	0.11	0.29	0.21	----	<0.1	<0.1	0.12	----	----	<0.1	1.1	2.6	2.1	0.41	0.54	0.39	<0.1
SULFATE	6.3	5.6	8.1	25	14	28	42	49	48	36	17	12	15	45	42	41	44
ALKALINITY	270	420	380	320	360	420	340	390	340	340	290	100	200	190	180	400	380
TOTAL HARDNESS	370	320	370	370	460	430	410	450	550	380	360	120	200	510	330	510	540
AMMONIA	0.054	<0.03	----	----	<0.03	UJ	<0.03	----	----	<0.03	0.099	<0.03	---	---	<0.03	< 0.03	< 0.03
METHANE	3.3	7.8	2.8	1.5	0.51	0.14	0.07	0.051	0.28	0.045	0.29	<0.0021	0.0049	0.033	0.057	0.018	0.0082
PARAMETERS MEASURED IN THE FIELD																	
FERROUS IRON	2.2	1.1	3.5	0.8	2.9	0	0.0	0.8	0.0	0.0	1.6	0.0	0	5.2	3.5	1.6	1.2
pH	4.64	6.97	7.39	7.21	7.77	7.32	7.35	6.97	7.53	7.38	5	6.88	6.92	7.62	7.49	6.92	6.93
DISSOLVED OXYGEN	11.09	0.38	0.29	2.95	0.38	0	0.19	0.23	0.26	0.14	10.45	7.57	4.89	2.57	2.24	0.39	0.00
OXIDATION REDUCTION POTENTIAL	272	-66.1	-43.1	86.1	-107.1	-20	-58.7	-5.3	10.1	-6.0	255	99.8	21.4	-21.7	-17.7	27.6	-61
CONDUCTIVITY	0	0.567	817	0.956	1.128	1.66	0.558	1.404	0.850	0.854	0	0.490	0.845	0.915	1.238	1.033	2.160
FIELD OBSERVATIONS	Odor/sheen	Odor	Odor	Oxidant in H2O	----	----	----	----	----	----	----	----	----	----	----	----	

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WELL ID	**MW-109**		**MW-110**		**MW-111**				**MW-112**				**MW-113**		**MW-114**		**NYSDEC**
Sample Date	**Feb-08**	**Oct-09**	**Feb-08**	**Oct-09**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Feb-08**	**Apr-09**	**Aug-09**	**Oct-09**	**Feb-08**	**Oct-09**	**Feb-08**	**Oct-09**	**STANDARDS**
VOCs (ug/l)																	
BENZENE	< 1	<1	< 1	<1	< 1	<1	<1	<1	<20	**13**	**6.9**	< 10	<1	<1	<1	<1	1
ETHYL BENZENE	< 1	<1	< 1	<1	< 1	<1	<1	<1	**410**	**250**	**300**	**48**	<1	<1	<1	<1	5
TOLUENE	< 1	NA	< 1	NA	< 1	NA	NA	NA	<20	NA	NA	NA	NA	NA	NA	NA	5
XYLENE	< 1	<2	< 1	<2	< 1	<2	<2	<2	**740**	**480**	**170**	**<20**	<2	<2	<1	<2	5
MTBE	< 1	NA	< 1	NA	< 1	NA	NA	NA	<20	NA	NA	NA	NA	NA	NA	NA	10
NATURAL ATTENUATION PARAMETERS (mg/l)																	
NITRATE	0.66	<0.1	<0.1	<0.1	<0.1	----	----	<0.1	<0.1	----	----	1.4	----	<0.1	----	<0.1	NA
SULFATE	70	65	41	57	65	45	48	49	19	11	11	8.4	11	62	11	56	NA
ALKALINITY	410	340	370	380	350	360	330	360	370	360	330	340	330	470	330	350	NA
TOTAL HARDNESS	460	420	450	570	410	490	600	540	380	570	530	510	530	540	530	400	NA
AMMONIA	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	----	----	< 0.03	< 0.03	----	----	0.051	----	< 0.03	----	< 0.03	NA
METHANE	0.28	0.0078	0.048	0.061	0.044	0.04	0.051	0.039	7.2	3	1.6	1.4	1.6	0.021	1.6	0.0044	NA
PARAMETERS MEASURED IN THE FIELD																	
FERROUS IRON	0.0	0.2	0.4	0.0	0.0	0.0	0.2	0.0	1.3	2.1	2.2	0.0	1.7	1.5	1.8	1.4	NA
pH	6.95	7.49	7.14	7.54	7.23	7.34	7.24	7.21	7.25	8.30	6.57	7.33	7.06	7.19	6.90	7.12	NA
DISSOLVED OXYGEN	0.04	0.68	0.11	0.17	0.10	0.28	0.33	0.15	0.42	0.16	0.37	0.26	0.30	0.00	0.14	0.00	NA
OXIDATION REDUCTION POTENTIAL	162.5	59.1	0.4	30.7	14.7	22.3	28.8	27.9	-110.2	-74.6	-71.3	21.5	-57.8	-42.7	-43.3	-112	NA
CONDUCTIVITY	1.269	1.458	0.970	1.311	0.725	0.848	1.199	1.750	0.599	0.855	15.890	1.481	1.349	1.863	1.055	1.38	NA
FIELD OBSERVATIONS	----	----	----	----	----	----	----	----	Odor	Odor	Odor	Odor	----	----	artesian	artesian	----

NOTES:

ug/L = Micrograms per lite mg/L= Milligrams per liter

VOCs - volatile organic compounds determined by USEPA Method 8260

NYSDEC Standards - NYS Division of Water Technical and Operational Guidance Series (1.1.1) 1998

The MTBE ground water stardard is from NYSDEC's TAGM 8086

- Bold white type with black background indicates exceedance of the NYSDEC Standards or Guidance Value

J = Results greater than the reporting limit that are considered estimated.

UJ= Results less than the reporting limit that are considered estimated.

---- = the compound was not detected at a concentration above the laboratory reporting limit

Natural Attenuation Parameters are used to characterize the physical, chemical and biological response of a hydrologic system to contamination.

Dissolved Oxygen, Oxidation Reduction Potential, pH and conductivity were measured in the field using a Horiba U-22 and flow through cell just prior to collecting samples.

Ferrous Iron concentration were measured using a HACH Test Kit

Ferrous Iron and DO are reported in mg/L

pH is reported in standard units

Oxidation Reduction Potential is reported in mV

Conductivity is reported in ms/cm

Odor = "Petroleum-like" odc Sheen= Sheen on purge water and/or sample

Attachment B
Mann-Kendall Statistical Test

Mann-Kendall Statistical Test

Site Name	Hancock ANG	Well Number	MW-2

	Compound ->	Benzene	Ethylbenzene	Xylenes			
Event Number	Sampling Date (most recent last)	Concentration	Concentration	Concentration	Concentration	Concentration	Concentration
1	Jan-01	<1	320	900			
2	Oct-01	<2	180	340			
3	Apr-05	<1	4	2			
4	Sep-05	<1	83	98			
5	Nov-06	<2	52	44			
6	Feb-08	<1	1	1			
7	Oct-09	<1	200	370			
8							
9							
10							

Mann Kendall Statistic (S) =		-7.0	-7.0			
Number of Rounds (n) =		7	7			
Average =		119.93	250.71			
Standard Deviation =		118.129	325.075			
Coefficient of Variation(CV)=		0.985	1.297			

Error Check, Blank if No Errors Detected

Trend ≥ 80% Confidence Level		DECREASING	DECREASING			
Trend ≥ 90% Confidence Level		No Trend	No Trend			
Stability Test, If No Trend Exists at 80% Confidence Level		NA	NA			

Data Entry By =	MCL	Date =	19-Nov-09	

Mann-Kendall Statistical Test

Site Name	**Hancock ANG**	Well Number	**MW-3**

	Compound ->	Benzene	Ethylbenzene	Xylenes			
Event Number	Sampling Date (most recent last)	Concentration	Concentration	Concentration	Concentration	Concentration	Concentration
1	Apr-05	200	200	95			
2	Sep-05	57	16	15			
3	Nov-06	75	61	28			
4	Feb-08	1	1	2			
5	Oct-09	1	1	2			
6							
7							
8							
9							
10							

Mann Kendall Statistic (S) =	-7.0	-7.0	-7.0			
Number of Rounds (n) =	5	5	5			
Average =	66.80	55.80	28.40			
Standard Deviation =	81.494	84.278	38.760			
Coefficient of Variation(CV)=	1.220	1.510	1.365			

Error Check, Blank if No Errors Detected

Trend ≥ 80% Confidence Level	**DECREASING**	**DECREASING**	**DECREASING**			
Trend ≥ 90% Confidence Level	**DECREASING**	**DECREASING**	**DECREASING**			
Stability Test, If No Trend Exists at 80% Confidence Level	NA	NA	NA			

Data Entry By =	MCL	Date =	19-Nov-09	

Mann-Kendall Statistical Test

Site Name	**Hancock ANG**	Well Number	**MW-11**

	Compound ->	Benzene	Ethylbenzene	Xylenes			
Event Number	Sampling Date (most recent last)	Concentration	Concentration	Concentration	Concentration	Concentration	Concentration
1	Jan-01	1	<1	<1			
2	Oct-01	18	3	<2			
3	Apr-05	32	<1	<1			
4	Sep-05	31	1	5			
5	Nov-06	17	0.63J	0.36J			
6	Feb-08	1	<1	<1			
7	Oct-09	49	11	16			
8							
9							
10							

Mann Kendall Statistic (S) =	4.0					
Number of Rounds (n) =	7					
Average =	21.29					
Standard Deviation =	17.462					
Coefficient of Variation(CV)=	0.820					

Error Check, Blank if No Errors Detected

Trend ≥ 80% Confidence Level	No Trend					
Trend ≥ 90% Confidence Level	No Trend					

Stability Test, If No Trend Exists at 80% Confidence Level	**CV <= 1** **STABLE**					

Data Entry By =	MCL	Date =	19-Nov-09	

Mann-Kendall Statistical Test

Site Name	**Hancock ANG**	Well Number	**MW-14**

Event Number	Compound -> Sampling Date (most recent last)	Benzene Concentration	Ethylbenzene Concentration	Xylenes Concentration	Concentration	Concentration	Concentration
1	Jan-01	1	<1	<1			
2	Oct-01	14	5	2			
3	Apr-05	4	<1	<1			
4	Sep-05	5	1	<1			
5	Nov-06	2	0.22J	<1			
6	Feb-08	1	< 1	< 1			
7	Oct-09	4	< 1	< 2			
8							
9							
10							

Mann Kendall Statistic (S) =	-2.0					
Number of Rounds (n) =	7					
Average =	4.30					
Standard Deviation =	4.504					
Coefficient of Variation(CV)=	1.047					

Error Check, Blank if No Errors Detected

Trend ≥ 80% Confidence Level	No Trend					
Trend ≥ 90% Confidence Level	No Trend					
Stability Test, If No Trend Exists at 80% Confidence Level	CV > 1 NON-STABLE					

Data Entry By =	MCL	Date =	19-Nov-09

Mann-Kendall Statistical Test

Site Name	**Hancock ANG**	Well Number	**MW-15**

Event Number	Compound -> Sampling Date (most recent last)	Benzene Concentration	Ethylbenzene Concentration	Xylenes Concentration	Concentration	Concentration	Concentration
1	Jan-01	1	2	<1			
2	Oct-01	150	92	82			
3	Apr-05	100	28	3			
4	Sep-05	140	33	<2			
5	Nov-06	66	38	<2			
6	Feb-08	6.8	2	<2			
7	Oct-09	10	11	<2			
8							
9							
10							

Mann Kendall Statistic (S) =	-5.0	-2.0				
Number of Rounds (n) =	7	7				
Average =	67.69	29.43				
Standard Deviation =	63.945	31.219				
Coefficient of Variation(CV)=	0.945	1.061				

Error Check, Blank if No Errors Detected

Trend ≥ 80% Confidence Level	No Trend	No Trend				
Trend ≥ 90% Confidence Level	No Trend	No Trend				

Stability Test, If No Trend Exists at 80% Confidence Level	**CV <= 1** **STABLE**	**CV > 1** **NON-STABLE**				

Data Entry By =	MCL	Date =	19-Nov-09

Mann-Kendall Statistical Test

Site Name	**Hancock ANG**	Well Number	**MW-19**

	Compound ->	Benzene	Ethylbenzene	Xylenes			
		Concentration	Concentration	Concentration	Concentration	Concentration	Concentration
Event Number	Sampling Date (most recent last)						
1	Jan-01	11	82	16			
2	Oct-01	23	450	440			
3	Apr-05	28	300	650			
4	Sep-05	33	610	860			
5	Nov-06	17	270	460			
6	Feb-08	2	9	9			
7	Oct-09	0.71	380	420			
8							
9							
10							

Mann Kendall Statistic (S) =	-7.0	-1.0	-1.0			
Number of Rounds (n) =	7	7	7			
Average =	16.39	300.07	407.86			
Standard Deviation =	12.495	207.524	310.807			
Coefficient of Variation(CV)=	0.762	0.692	0.762			

Error Check, Blank if No Errors Detected

Trend ≥ 80% Confidence Level	**DECREASING**	No Trend	No Trend			
Trend ≥ 90% Confidence Level	No Trend	No Trend	No Trend			

Stability Test, If No Trend Exists at 80% Confidence Level	NA	**CV <= 1** **STABLE**	**CV <= 1** **STABLE**			

Data Entry By =	MCL	Date =	19-Nov-09	

Mann-Kendall Statistical Test

Site Name	**Hancock ANG**	Well Number	**MW-22**

	Compound ->	Benzene	Ethylbenzene	Xylenes			
Event Number	Sampling Date (most recent last)	Concentration	Concentration	Concentration	Concentration	Concentration	Concentration
1	Oct-01	22	14	32			
2	Apr-05	110	89	88			
3	Sep-05	70	32	46			
4	Nov-06	51	82	90			
5	Feb-08	1	1	1			
6	Oct-09	6	21	3			
7							
8							
9							
10							

Mann Kendall Statistic (S) =	-7.0	-3.0	-3.0			
Number of Rounds (n) =	6	6	6			
Average =	43.27	39.83	43.33			
Standard Deviation =	42.155	36.842	39.312			
Coefficient of Variation(CV)=	0.974	0.925	0.907			

Error Check, Blank if No Errors Detected

Trend ≥ 80% Confidence Level	**DECREASING**	No Trend	No Trend			
Trend ≥ 90% Confidence Level	No Trend	No Trend	No Trend			

Stability Test, If No Trend Exists at 80% Confidence Level	NA	**CV <= 1** **STABLE**	**CV <= 1** **STABLE**			

Data Entry By =	MCL	Date =	19-Nov-09	

Mann-Kendall Statistical Test

Site Name	**Hancock ANG**	Well Number	**RW-1**

	Compound ->	Benzene	Ethylbenzene	Xylenes			
Event Number	Sampling Date (most recent last)	Concentration	Concentration	Concentration	Concentration	Concentration	Concentration
1	Apr-05	<1	11	21			
2	Sep-05	2	18	36			
3	Nov-06	1.4J	60	30			
4	Feb-08	<2	45	60			
5	Oct-09	<1	1	2			
6							
7							
8							
9							
10							

Mann Kendall Statistic (S) =		0.0	0.0			
Number of Rounds (n) =		5	5			
Average =		27.00	29.80			
Standard Deviation =		24.627	21.218			
Coefficient of Variation(CV)=		0.912	0.712			

Error Check, Blank if No Errors Detected

Trend ≥ 80% Confidence Level		No Trend	No Trend			
Trend ≥ 90% Confidence Level		No Trend	No Trend			
Stability Test, If No Trend Exists at 80% Confidence Level		**CV <= 1** **STABLE**	**CV <= 1** **STABLE**			

Data Entry By =	MCL	Date =	19-Nov-09

Attachment C
Calculation of Apparent First Order Attenuation Rate Constants

MW-2

Calculation of Apparent First Order Attenuation Rate Constants

$$C_t = C_o * e^{-r\,t}$$

$$\ln(C_t/C_o) = -rt$$

where:

C_t = Concentration at time t in years

C_o = Initial concentration

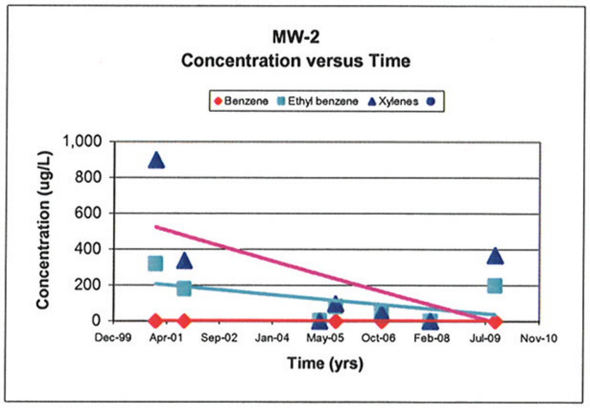
t = Time in years

r = Apparent first order rate constant (per year)

MW-2	Benzene	Ethyl Benzene	Xylenes
Rate Contant (per yr)	na	0.27	0.35
Half-life (yrs)	na	2.5	2.0
Concentration (ug/L)	<1	83.0	98.0
Est. End Point (ug/L)	1	5	5
Time to End Point (yrs)	na	10.29	8.60

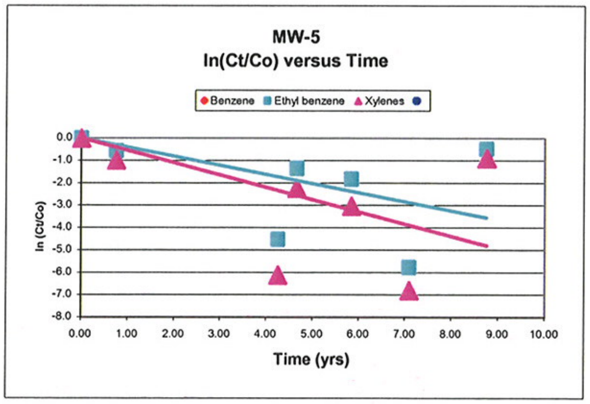
Concentration versus Time

Date	Benzene ug/L	Ethyl benzene ug/L	Xylenes ug/L
Jan-01	<1	320.0	900
Oct-01	<2	180	340
Apr-05	<1	4	2
Sep-05	<1	83	98
Nov-06	<2	52	44
Feb-08	<1	1	1
Oct-09	<1	200	370



Natural Logarithm (Ct/Co) versus Time

Time (yrs)	Benzene ln(Ct/Co)	Ethyl benzene ln(Ct/Co)	Xylenes ln(Ct/Co)
0.00		0.00	0.00
0.75		-0.58	-0.97
4.26		-4.52	-6.11
4.67		-1.35	-2.22
5.85		-1.82	-3.02
7.10		-5.77	-6.80
8.75		-0.47	-0.89



MW-3 Calculation of Apparent First Order Attenuation Rate Constants

$$C_t = C_o * e^{-r\,t}$$

$$\ln(C_t/C_o) = -rt$$

where:

C_t = Concentration at time t in years

C_o = Initial concentration

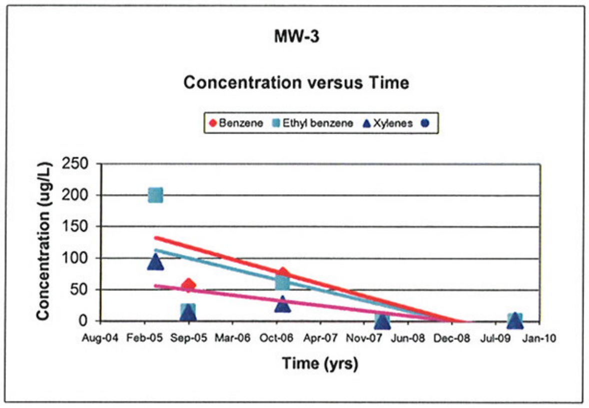
t = Time in years

r = Apparent first order rate constant (per year)

MW-3	**Benzene**	**Ethyl Benzene**	**Xylenes**
Rate Contant (per yr)	1.25	1.11	0.85
Half-life (yrs)	0.6	0.6	0.8
Concentration (ug/L)	1.00	1.0	1.0
Est. End Point (ug/L)	1	5	5
Time to End Point (yrs)	na	na	na

Concentration versus Time

Date	**Benzene ug/L**	**Ethyl benzene ug/L**	**Xylenes ug/L**
Apr-05	200	200.0	95
Sep-05	57	16	15
Nov-06	75	61	28
Feb-08	1	1	1
Oct-09	1	1	2



Natural Logarithm (Ct/Co) versus Time

Time (yrs)	**Benzene ln(Ct/Co)**	**Ethyl benzene ln(Ct/Co)**	**Xylenes ln(Ct/Co)**
0.00	0.00	0.00	0.00
0.41	-1.26	-2.53	-1.85
1.59	-0.98	-1.19	-1.22
2.84	-5.30	-5.30	-4.55
4.49	-5.30	-5.30	-3.86