ARCADIS

Infrastructure · Water · Environment · Buildings

ARCADIS of New York, Inc.
Two Huntington Quadrangle
Suite 1S10
Melville
New York 11747
Tel 631.249.7600
Fax 631.249.7610
www.arcadis-us.com

ENVIRONMENT

Mr. George Jacob
United States Environmental Protection Agency – Region 2
290 Broadway, 20th Floor
New York, New York 10007-1866

Subject:
Focused Feasibility Study (FFS) Report,
Colesville Landfill, Colesville, New York. (Site No. 704010).

Date:
April 23, 2012

Contact:
Steven M. Feldman

Phone:
(631) 391-5244

Email:
steven.feldman@arcadis-us.com

Our ref:
NY000949.0025.00005

Dear Mr. Jacob:

On behalf of Broome County, ARCADIS is providing the report entitled, "Focused Feasibility Study (FFS), Colesville Landfill, Colesville, New York." The FFS has been prepared to reevaluate whether the site-wide remedies for groundwater and associated affected media (i.e., spring water and surface water) described in the Explanation of Significant Differences, dated September 2000 and July 2004, are warranted and cost-effective in light of current Site conditions at this stage of the remedial lifecycle, and if not, to evaluate and propose a more appropriate alternative remedy.

Please contact me if you have any questions. We look forward to discussing our technical evaluations and recommended alternative remedy upon your review.

Sincerely,

ARCADIS of New York, Inc.

Steven Feldman

Steven M. Feldman
Project Manager

Copies:
Laurie Haskell, Broome County
Dan Schofield, Broome County
Payson Long, NYSDEC
Julia Kenney, NYSDOH
File

Imagine the result

Broome County
Division of Solid Waste management

Focused Feasibility Study

Colesville Landfill
Colesville, New York

April 23, 2012

Focused Feasibility Study

Colesville Landfill
Colesville, New York
NYSDEC Site 704010

Christine Casella
Staff Environmental Engineering Specialist

Kenneth Zegel, P.E.
Senior Engineer

Steven M. Feldman
Project Director

Prepared for:
Broome County Division of Solid Waste Management

Prepared by:
ARCADIS of New York, Inc.
Two Huntington Quadrangle
Suite 1S10
Melville
New York 11747
Tel 631 249 7600
Fax 631 249 7610

Our Ref.:
NY000949.0025.00005

Date:
April 23, 2012

Tables

Figures

Appendices

Certification

I, Kenneth Zegel, certify that I am currently a NYS registered professional engineer and that this Focused Feasibility Study Report was prepared in accordance with all applicable statutes and regulations and in substantial conformance with the DER-10 Technical Guidance for Site Investigation and Remediation (DER-10).

Kenneth Zegel, P.E.
Senior Engineer
License # 081598-1

1. Introduction

ARCADIS of New York, Inc., (ARCADIS) on behalf of Broome County has prepared this Focused Feasibility Study (FFS) for groundwater and associated affected media (i.e., spring water and surface water) at the Colesville Landfill site (Site), located in Broome County, New York. This FFS was prepared to reevaluate the appropriateness of the site-wide remedies described in the Explanation of Significant Differences (ESDs), dated September 2000 and July 2004, respectively. The reevaluation is warranted based upon:

- A shift in paradigm for mass transport within the hydrogeologic community that significantly affects the estimated and/or expected overall remedial timeframe for a site.
- The current status of remedial progress and effectiveness of installed remedial components that have been implemented subsequent to issuance of the Record of Decision (ROD) Remedy (USEPA 1991) and ESDs.
- The calculation of the site-specific mass transport rate based upon actual field data collected during implementation of the ROD remedy.

Based upon the above, Broome County requested the opportunity to evaluate whether the current groundwater and spring remedies described in the ESDs are the most appropriate remedy for the Site at this point in the remedial lifecycle. The United States Environmental Protection Agency (USEPA), Region II, and New York State Department of Environmental Conservation (NYSDEC) concurred with this request.

This FFS is organized in seven sections, as follows:

- Section 1.0 Introduction
- Section 2.0 Summary of Current Conditions
- Section 3.0 Remedial Goals and Remedial Action Objectives
- Section 4.0 Identification and Screening of Remedial Technologies
- Section 5.0 Development and Analysis of Remedial Alternatives

- Section 6.0 Recommended Remedy
- Section 7.0 References

1.1 Purpose and Objectives

As described on page twenty four (24) of the ROD under the Selected Remedy, “It may become apparent, during the operation of the groundwater extraction system that, at a certain point, contaminant levels have ceased to decline and are remaining constant at levels higher than the remedial goal. In such a case, the system performance standards and/or the remedy will be reevaluated.” Accordingly, the purpose and objective of this FFS is to evaluate a more cost-effective and warranted remedial alternative that will restore groundwater quality to maximum contaminant levels (MCLs) in an acceptable timeframe while ensuring continued protection of human health and ecological receptors during this groundwater remediation timeframe. This FFS will document the following:

- The effectiveness of the landfill cap at eliminating the landfill as a continuing source of contamination;
- The remedial progress achieved to date through the establishment of an anaerobic in-situ reactive zone (IRZ);
- The relative ineffectiveness of the pump-and-treat technology in removing volatile organic compound (VOC) mass from the subsurface;
- The insignificant estimated quantity of dissolved phase mass remaining in the downgradient plume as of September 2011 indicating that continued operation of the active remedy is not cost effective; and
- A revised conceptual site model (CSM) that was refined through evaluation of existing remedial system performance monitoring data and is strongly supported academically through a shift in paradigm for mass transport within the hydrogeologic community. The revised CSM and paradigm shift significantly affect the estimated and/or expected overall remedial timeframe for groundwater at the Site using the current anaerobic IRZ.

Ultimately, this FFS will document that a more passive, green remediation approach is equally protective of human health and the environment as the current remedy and will achieve the ROD-driven remedial action objectives (RAOs) within a comparable remedial timeframe.

2. Summary of Current Conditions

This section provides the following:

- A description of the Site;
- A summary of the hydrogeologic framework for the Site including a description of the revised CSM for mass transport;
- A description of the current remedy components and their effectiveness; and
- A summary of current groundwater quality.

2.1 Site Description

The Colesville Landfill is located in the Town of Colesville, Broome County, New York. The property on which the landfill is situated is generally bounded by East Windsor Road to the west and by unnamed tributaries of the Susquehanna River to the north, west, and east. The tributary to the north (DEC Tributary 120) is commonly referred to as the North Stream and is shown on Figure 1-1. The property consists of approximately 113 acres, 35 of which, located in the northern and western areas, were utilized for landfill operations.

Waste disposal operations were conducted at the Site from 1969 to 1984. The Town of Colesville owned and operated the Site from 1969 to 1971. In 1971, Broome County became the owner of the Site. Broome County operated the landfill from 1971 until it was closed in 1984 (Wehran 1988).

The landfill was primarily used for the disposal of municipal solid waste. However, between 1973 and 1975, industrial waste consisting primarily of drummed aqueous dye wastes, as well as organic and chemical solvent mixtures were also disposed at the landfill (Wehran 1988). The primary disposal practice utilized during the operational life of the landfill was the trench method. Approximately ninety three (93) percent of the material disposed at the Site was disposed in this way. The remaining seven (7) percent was disposed by utilizing the area method (Wehran 1988).

2.2 Hydrogeologic and Hydrologic Setting

A complete description of the hydrogeologic and hydrologic setting is presented in Section 2.2 of the 1996 Revised Focused Feasibility Study (Geraghty & Miller 1996). Two aquifers have been identified in the vicinity of the Site: the glacial outwash aquifer and the bedrock aquifer. These aquifers are separated by low permeability glaciolacustrine silt and clays and glacial till. In this type of hydrogeologic setting, a very high percentage of the areal recharge to the glacial outwash aquifer moves horizontally because of the dense glaciolacustrine clay confining unit that underlies the glacial outwash aquifer. Water moving within the glacial outwash aquifer beneath the landfill is part of a shallow groundwater subsystem that discharges into nearby surface-water bodies. The direction of groundwater flow at the Colesville Landfill site is toward the west and southwest, discharging to the North Stream and Susquehanna River. Although groundwater is present in the till and glaciolacustrine clay, the low permeabilities of these units limits their potential for groundwater flow.

Historical aquifer testing indicates that the glacial outwash aquifer in the area of interest has a low permeability (approximately 0.2 to 0.3 feet per day (ft/day) and poor ability to yield water (0.25 to 0.5 gallons per minute (gpm)). The historical horizontal groundwater gradient ranges from 0.05 to 0.07 foot per foot (ft/ft). Assuming a mobile porosity range of three (3) percent to seven (7) percent (which is typical for glacial tills (Driscoll 1986), the calculated advective groundwater velocity ranges from 0.3 ft/day to 0.5 ft/day at the Site.

2.2.1 Hydrogeologic Paradigm Shift and Remedy Based Hydrogeologic Observations and Evaluations

Environmental remediation literature published subsequent to the selection of the ROD remedy has documented a significant shift in paradigm of contaminant mass transport behavior and relative cleanup times. Specifically, it is now well understood that for most sites, mass transport is primarily governed by diffusion and the complex interaction between aquifer mass storage zones (e.g., immobile porosity/secondary porosity and low aquifer hydraulic conductivity architecture) and aquifer mass transport zones (e.g., mobile porosity and high hydraulic conductivity architecture). In contrast, previous mass transport theories and models assumed that dispersion and retardation due to carbon partitioning were the primary mechanisms controlling mass transport. While dispersion and carbon partitioning play a small role in mass transport, they are typically insignificant under most hydrogeologic settings. The primary factors in mass transport or plume behavior are plume age, the variability in hydrogeologic architecture (i.e., number of transitions or lenses of high hydraulic conductivity to low hydraulic conductivity media within a vertical section of aquifer), and the ratio of total porosity to mobile porosity. These concepts are described in detail in *Remediation Hydraulics* (Payne et al., 2008). Ultimately, these concepts, as a general rule, explain why traditional site remedies such as groundwater extraction are extremely inefficient at mass removal and explain why the actual estimated remedial timeframes at most sites are much longer than initially anticipated or modeled. The concepts also reveal that the rate of mass transport is typically much lower using the new paradigm when compared to the previous standard transport models.

Performance monitoring data from the existing anaerobic IRZ has provided invaluable insight into the mass transport behavior at the Site. Specifically, the monitoring of total organic carbon (TOC) introduced into the aquifer as part of ongoing anaerobic IRZ implementation and the monitoring of the inert tracer bromide as part of the Alternate Electron Donor Pilot Test (ARCADIS G&M, Inc. 2006) were used to estimate the rate of advective groundwater velocity and estimate the rate of overall mass transport. As a general rule, the initial observation of an injected solute at relatively low concentration at nearby downgradient monitoring locations corresponds to the advective groundwater velocity because the solute has not had an opportunity to transfer into mass storage zones. The long-term behavior of solute mass, or the time to reach the center of solute mass at a location downgradient from the injection point, represents the overall mass transport rate as it accounts for the processes that drive mass retardation. Ultimately, TOC and bromide monitoring data support an advective groundwater transport velocity in the range of 0.3 ft/day to 0.5 ft/day, which is consistent with previous hydrogeologic data. However, these data also support an average mass transport rate of approximately 0.03 ft/day to 0.05 ft/day. When compared to current literature, these data correlate well to the overall hydrogeologic setting at the Site and the complex hydrogeologic architecture comprised of significant variability in vertical strata with varying conductivities and a high proportion of immobile to mobile porosity. However, the data indicate that groundwater cleanup times will be significant and will be dictated by the rate of mass transfer from the mass storage zones to the mass transfer zones, irrespective of remedial technology implemented. The revised CSM provides a significant challenge to expediting groundwater remediation within a reasonable timeframe; however, it also supports the fact that groundwater mass transport rates are extremely low and easily tracked using a monitoring only or similar approach.

2.3 Description of Current Remedy

This section provides a brief overview of the remedial chronology and a summary of the current remedy components related to groundwater and associated media (e.g., spring water and surface water).

2.3.1 History of Current Remedy

In 1991, the USEPA issued the ROD Remedy , which included (1) installation of a landfill cap; (2) construction of a gas venting layer; (3) installation of groundwater extraction wells beneath and downgradient of the landfill; (4) ex-situ groundwater treatment; (5) surface-water discharge to either the Susquehanna River or to the North Stream, a tributary of the Susquehanna River; (6) fencing to restrict access to the Site; (7) imposition of property deed restrictions, if necessary; (8) development and construction of a new water supply system (which may include a new well or wells) for impacted residential wells in the area that remain in use, and (9) implementation of a monitoring program upon completion of closure activities to provide data to evaluate the effectiveness of the remedial effort over time.

Installation of the landfill cap was completed in November 1995. Based upon design-related aquifer tests conducted at the Site, it was determined that extracting contaminated groundwater, as called for in the ROD, would not likely be an effective means of remediating groundwater in a reasonable timeframe. This conclusion led to an evaluation of alternative groundwater remediation technologies. Based upon this evaluation and a pilot-scale study of anaerobic IRZ technology, it was concluded that this technology, in combination with the installation of downgradient extraction wells, offered a more technically feasible approach for achieving RAOs. A final groundwater remediation design was approved by NYSDEC on August 24, 2000. The ESD to change the ROD remedy was issued in September 2000, and the remedy has been operating since 2002.

2.3.2 Landfill Cap

The landfill cap consists of a multimedia cap over the landfill material that attains the performance requirements for caps at hazardous waste landfills as specified in the Code of Federal Regulations (CFR) Part 264.310. It provides for long-term minimization of migration of liquids through the closed landfill by establishing proper slopes for drainage of precipitation, vegetated topsoil to promote evapotranspiration, and installation of a flexible membrane liner (FML) with a permeability of 1×10^{-12}

centimeters per second. The objective of the landfill cap is to prevent stormwater infiltration into the landfill thereby eliminating further contaminant migration from vadose zone soils (e.g., contamination from buried waste) into groundwater.

2.3.3 Groundwater Extraction System

The groundwater extraction system consists of three recovery wells (GMPW-3, GMPW-4, and GMPW-5) and associated pneumatic pumps that extract groundwater at a combined flow rate of approximately 0.5 gpm. The well pump for recovery well GMPW-3 was removed from operation on January 7, 2010 as a result of well fouling and associated pump failure. With prior USEPA approval, recovery well GMPW-3 has remained offline. The pneumatic pumps deliver the extracted groundwater through one-inch diameter high-density polyethylene (HDPE) pipes to a treatment building, and into the top of a low-profile air stripper (AS-100). The low-profile air stripper off-gas is discharged through a six-inch diameter Schedule 40 PVC stack to the atmosphere. The treated groundwater collects in the low-profile air stripper sump, and is then pumped through two cartridge filter housings (BF-400, BF-401). Each of the two cartridge filter housings contains seven, five-micron filters that remove iron and silicate particulates. The treated groundwater is then discharged to the swale that conveys water to the North Stream.

2.3.4 Enhanced Reductive Dechlorination

An automated reagent injection (ARI) system was installed within the treatment building to serve as the means for delivering organic carbon to the subsurface to establish conditions conducive for enhanced reductive dechlorination (ERD). The ARI system consists of two raw molasses-whey (mol-whey) blend storage tanks (ST-700, ST-701), a temporary 20,000-gallon water holding tank, a mixing tank (MT-800), and an associated controls and instrumentation system to automate the injection process. Currently, injections are completed using a one (1) percent by volume mol-whey blend as the electron donor. The diluted mol-whey solution is pumped into seventeen (17) injection wells located along the perimeter of the landfill with injections completed every six (6) to eight (8) months.

2.3.5 SP-5 Spring Water Remediation System

The SP-5 spring water remediation system consists of a sand filter and granular activated carbon unit that were placed in an existing three (3) foot diameter concrete structure that extends two and a half (2.5) feet below ground surface. Groundwater flows upward via the ambient hydraulic gradient through the concrete structure, through an additional filter, and discharges through a four (4) inch diameter horizontal drainage pipe run through the side of the concrete structure. A rip-rap lined outlet structure to prevent erosion was installed at the discharge point of the drainage pipe.

SP-5 maintenance/modifications were implemented during September 2008 to mitigate the presence of tailwater at the SP-5 discharge outfall. Specific modifications included the installation of a subsurface clay barrier immediately downgradient of the existing SP-5 carbon unit and the extension of the SP-5 discharge pipe to a location approximately twelve (12) feet to the southwest of the existing outfall location.

2.3.6 SP-4 Spring Water Remedy

The remedy for the spring at SP-4 consisted of the installation of a subsurface stone infiltration bed in the area of the spring to prevent the contaminated spring water from exfiltrating above the land surface. Large boulders were placed between the stream and the infiltration bed to protect the integrity of the infiltration bed during high water conditions. These actions, which were performed by ARCADIS, were documented by USEPA in a July 2004 ESD.

This subsurface stone infiltration bed in the area of the SP-4 spring was damaged during a flood event in May 2006. The infiltration bed was repaired and extended by ARCADIS during the second quarter of 2007, and a heavy stone retaining wall was also installed along a larger stretch of the North Stream by a Federal Emergency Management Agency (FEMA) contractor as an erosion control measure. In addition, the stream channel was realigned as part of this effort.

Improvements to the SP-4 spring area were completed in October 2011. These improvements were implemented to enhance hydraulic control of the SP-4 spring and to eliminate the potential direct exposure risk to ecological receptors. The existing high permeability media was extended to the North Stream so that near-surface water will be redistributed within the high permeability media and groundwater table, and exfiltration of the spring above land surface will be prevented. Inspections of the SP-4 area in December 2011 have provided confirmation that these improvements are consistent with the original design intent of the system and have eliminated the exfiltration of groundwater at SP-4.

2.3.7 Bedrock Residential Water Supply Wells

Following issuance of the ROD, Broome County installed double-cased bedrock wells for the two residences on the Charles Scott parcel (referred to as the Charles Scott Sr. and River residences). The Charles Scott Sr. residence is abandoned and dilapidated, and the River residence (Claude Scott) is currently occupied. The bedrock wells were installed to provide the residents with a clean drinking water supply.

2.3.8 Institutional Controls

Following issuance of the ROD, the NYSDEC and the USEPA approved the Broome County and GAF Corporation (i.e., Principal Responsible Parties [PRPs]) proposal to undertake a program of acquiring the residential properties where wells were impacted by VOCs (the contaminants of concern [COCs]) as an alternative to implementing the new water supply required by the ROD. The impacted residential properties are or were owned by the DeFreitas family, Harry Ray Scott (Riley), the Smith family, and Charles Scott. The DeFreitas and Smith properties have already been purchased and have been vacated; negotiations to purchase the Harry Ray Scott and Charles Scott properties were not successful, and as previously mentioned the residences on the Charles Scott parcel were provided with bedrock wells (See Section 2.3.7). The Harry Ray Scott residence is abandoned and dilapidated. Moreover, deed restrictions on groundwater use will be recorded for Broome County-owned properties, and the U.S. EPA is currently pursuing a mechanism to restrict groundwater use on properties (“USEPA-mandated groundwater use restrictions on private parcels”) not controlled by Broome County.

2.3.9 Engineering Controls

Engineering controls currently implemented for each remedy described in the previous sections are as follows:

- Landfill Cap:
    - Routine inspections of the landfill cap; and
    - Routine certification of proper cap operation.
- Spring water inspections along the North Stream.

- o Routine surveys and inspections of the North Stream and SP-4 area are completed to observe for the presence of new and/or existing springs.

2.3.10 Groundwater Monitoring Program

Long-term monitoring (LTM) activities (which include environmental effectiveness and remediation system performance monitoring) are performed in accordance with the LTM Plan (ARCADIS G&M, Inc. 2002), LTM Plan Addendum for Spring Water Remediation Systems (ARCADIS G&M, Inc. 2003), Interim Remedial Action Report (ARCADIS G&M, Inc. 2004), and the Proposed Modifications to the Long Term Monitoring Program (ARCADIS G&M, Inc. 2005) which were approved by the USEPA and NYSDEC. These documents provide a detailed description of the LTM program, methodology, and rationale. Where applicable these elements are either summarized or incorporated by reference herein. The objective of the LTM activities is to monitor and document remedy performance and track overall plume stability. In addition, Broome County collects samples from a residential monitoring network for analytical testing on a quarterly basis.

2.3.11 Summary of Current Groundwater Remedy Effectiveness

The current groundwater remedy is effective in the protection of human health and the environment but is no longer an efficient means of removing bulk mass from the Site under the revised hydrogeologic and mass transport understanding. The following conclusions support this statement:

- The landfill cap has proved an effective means for eliminating the landfill as a continuing source of contamination;

- The groundwater extraction system removes negligible contaminant mass, provides no hydraulic containment and has an overall limited effectiveness;

- Although the ARI system effectively enhances the degradation of VOC mass, the estimated quantity of contaminant mass removed is relatively insignificant when compared to sites with a more favorable hydrogeologic framework for remediation;

- The SP-5 spring water remediation system is successfully treating VOCs to below their Best Professional Judgment limits via granular activated carbon (GAC) treatment, thereby eliminating the SP-5 spring as a potential location for direct exposure risk to ecological receptors;

- The SP-4 spring water remedy is successfully eliminating potential direct exposure risk to ecological receptors; and

- Institutional controls, residential bedrock supply wells and the groundwater monitoring program collectively eliminate risk to public health by preventing use of contaminated groundwater as a drinking water source.

Furthermore, the timeframe for aquifer restoration is not a critical element for remedy effectiveness because of the elimination of drinking water receptors of VOC-impacted groundwater from the glacial outwash aquifer (through property acquisition and/or installation of double-cased bedrock wells). The North Stream is the only surface-water body potentially impacted by groundwater quality at the Site, but concentrations of VOCs detected in the North Stream have never exceeded NYSDEC Ambient Water Quality Standards and Guidance Values (SW-SGVs).

A more detailed description in support of these conclusions is provided below.

2.3.11.1 Landfill Cap

Performance of the landfill cap is currently being monitored through evaluation of historical VOC data at monitoring well GMMW-7. Monitoring well GMMW-7 is located at the landfill boundary, upgradient of the injection transect (Figure 1-1). As evidenced by the VOC concentration trends at monitoring well GMMW-7 (see Section 2.5), VOC-impacted groundwater continues to migrate from beneath the capped landfill. This indicates that groundwater quality cannot be restored to MCLs in an expedited timeframe.

Historical VOC data at monitoring well GMMW-7 indicate a decline in total VOC concentrations; however, total VOC concentrations remain elevated fifteen (15) years after installation of the cap. This decline in total VOC concentration indicates that the cap likely eliminated the landfill as a source of groundwater contamination. The residual contamination currently being detected at monitoring well GMMW-7 is suspected to be the result of pre-existing contaminated groundwater flowing from beneath the landfill. Residual contamination is expected to eventually be completely eliminated through natural attenuation processes and groundwater flow; however, the data also show that there will be a continuing mass flux of contamination from beneath the cap. This mass flux makes it technically impracticable to achieve MCLs in a reasonable timeframe because of continued migration of contaminant mass from underneath the capped landfill.

2.3.11.2 Groundwater Extraction System

The total volume of groundwater recovered by the groundwater extraction system through Operational Year 8 is 2,166,956 gallons (ARCADIS 2011b). The mass removed by the groundwater extraction system between start-up in 2002 and the June 2011 monitoring event is 3.66 pounds (ARCADIS 2011b), or approximately 0.4 pounds per year. The PT system has only limited effectiveness because of the poor permeability of the formation and resultant low well yield, and drawdown that does not propagate far from the wells. The site conditions significantly limit the effectiveness of the pump and treat technology from removing contaminant mass and achieving MCLs.

As indicated by Figure 2-2, VOC concentrations at the groundwater extraction system pumping wells (GMPW-3 through GMPW-5) show stable to decreasing trends. Pumping well GMPW-3 has shown a forty three (43)-percent decrease in total VOC concentrations since start-up of the groundwater extraction system, and pumping well GMPW-4 has shown a sixty nine (69)-percent decrease. There have been no compounds detected at pumping well GMPW-5 for the past four (4) years of operation, which indicates that this well provides no mass removal benefit to the overall site remediation.

Downgradient monitoring well PW-4 has shown a ninety two (92)-percent decrease in total VOC concentrations since July 2002, and values have remained stable for the past six (6) years of operation (Figure 2-2). Data at monitoring well PW-4 indicate that the technical limit of mass reduction through pumping has been reached. That is, the current asymptote represents the extremely inefficient process of mass transfer from mass storage zones to mass transport zones through diffusion. Combined, these data indicate that groundwater extraction is not an efficient method for VOC mass removal from the downgradient groundwater.

2.3.11.3 Enhanced Reductive Dechlorination

Ongoing analytical results and field parameter measurements indicate that geochemical conditions in the current area of ARI system influence exhibit sufficient TOC, elevated chlorinated VOC degradation products (i.e., ethene and ethane), and elevated reduced forms of alternate electron acceptors (i.e., methane). The data provide strong evidence that VOCs are being significantly degraded within the IRZ along the downgradient flow path.

Concentrations of PCE daughter compounds, ethene, methane, and TOC versus time for select monitoring wells are provided in Figures 2-3 through 2-7. Likewise, the concentrations of TCA daughter compounds, ethane, methane, and TOC versus time for select monitoring wells are provided in Figures 2-8 through 2-12. Analytical data show that monitoring wells in close proximity to the anaerobic IRZ (i.e., GMMW-5, W-5, GMMW-6 and GMMW-2) have exhibited declining VOC concentrations when compared to historic analytical results, and total VOC concentrations have remained significantly lower than baseline conditions. The average concentration of total VOCs has decreased seventy six (76) percent, and the average concentration of PCE and its degradation compounds (i.e., TCE, 1,2-dichloroethene (1,2-DCE), and vinyl chloride) has decreased ninety five (95) percent. Of particular note is monitoring well GMMW-6, which has historically, by a significant margin, contained the highest concentrations of contaminants at the Site. Since reaching its maximum observed concentration of TVOCs in April 2003, the concentration of TVOCs at GMMW-6 has decreased ninety (90) percent. The concentration of chlorinated ethenes (i.e., PCE, TCE, 1,2-DCE, and VC) have decreased 98 percent when making the same comparison. Relative changes in the concentration of TCA-related daughter compounds when compared to baseline conditions for key monitoring wells are as follows:

- GMMW-2 – Overall decrease of 56 percent.
- GMMW-6 – Overall decrease of 58 percent.
- W-5 – Overall decrease of 40 percent.
- TW-1 – Overall decrease of 57 percent.

Collectively, this data indicate that the dissolved-phase plume continues to be stable and that the anaerobic IRZ is significantly degrading contaminant mass.

Concentrations of biodegradation end products (i.e., methane and ethane) in monitoring wells indicate the continued occurrence of bioactivity and biodegradation of VOCs within the IRZ. The concentration of ethane at monitoring well GMMW-5 continues to be elevated when compared to baseline conditions. GMMW-5 is located closest to the ARI injection wells and would be expected to be the first well to exhibit increases in biodegradation end products. Ethene results for monitoring well GMMW-6 remain elevated and continue to indicate that the IRZ extends to the vicinity of this well. Monitoring well GMMW-2 exhibits a gradual decrease in PCE related daughter compounds and concentrations of ethane and ethene continue to be elevated. This provides evidence that the monitoring well GMMW-2 location continues to be affected by groundwater that has been treated within the IRZ located upgradient of the GMMW-2 location.

Table A-1 provides an evaluation of the estimated mass removed by the ARI system since the first injection in September 2002. The mass removed by the ARI system is approximately twelve (12) pounds. The data show that over the nine (9) years that the systems have been in operation, the ARI system has removed approximately 300-percent more mass than the groundwater extraction system; therefore, operating the groundwater extraction system concurrently with the ARI system provides little benefit to maximizing mass removal efficiency. The data demonstrate that although the ARI system is extremely effective at destroying contaminant mass within its influence area, the extremely low rate of mass transport and mass flux into the treatment zone significantly limits the overall volume of mass degradation at the Site.

2.3.11.4 SP-5 Spring Water Remediation System

The SP-5 spring water remediation system consistently treats all effluent VOCs to below their respective Best Professional Judgment limits via the granular activated carbon. Influent TVOC analytical data has remained consistent with historical data (Figure 2-2); typically between 30 ug/L and 55 ug/L total VOCs). The SP-5 spring water remediation system has treated an estimated 3,490,297 gallons of spring water and has recovered an estimated 1.88 lbs of VOC mass since system startup.

2.3.11.5 SP-4 Spring Water Remedy

Water quality at the SP-4 spring location has significantly improved over time as evidenced by a significant decrease in total VOC concentrations since 2002 (ARCADIS 2010). Current SP-4 total VOC concentrations are typically below the limits of detection. This decrease in total VOC concentrations is the result of improved water quality at the spring through operation of the ARI system. As discussed in the Ecological Screening of Spring Water and Surface Water (ARCADIS 2010) current spring water quality at the SP-4 location demonstrates that a potential adverse effect to aquatic organisms is not present. Iron and manganese exceeded NYSDEC aesthetic-based water quality criteria, which are identified solely for aesthetic purposes of the water (i.e., clarity, color, taste, and odor) and are not related to the overall potential toxicity of the constituent to aquatic life. Elevated concentrations of iron and manganese in the spring water are likely the cause of the rust-colored water and sediment that was observed at the Site. It is important to note that iron and manganese are effectively removed from the water column because all co-located in-stream surface water samples and downstream samples (i.e., in-stream samples at the F-6 and F-8 locations) exhibited iron and manganese concentrations that are below applicable surface water quality criteria.

2.3.11.6 Bedrock Residential Water Supply Wells

Bedrock residential water supply wells for the two residences on the Charles Scott parcel (referred to as the Charles Scott Sr. and River residences) have successfully provided a clean drinking water source to these residents, thereby eliminating any risk to human health.

2.3.11.7 Institutional Controls

Institutional controls (i.e., deed restrictions) will eliminate risk to human health by preventing future use of contaminated groundwater as a drinking water source. Institutional controls will consist of deed restrictions on Broome County owned property and USEPA-mandated groundwater use restrictions on private parcels.

2.3.11.8 Groundwater Monitoring Program

The groundwater monitoring program ensures that concentrations of VOCs are monitored throughout the plume and remain consistent with the historical trend that the plume is stable to decreasing in size.

2.4 Summary of Groundwater, Spring Water and Surface Water Quality Data

This section provides a summary of current environmental data.

2.4.1 Groundwater

The overall stable plume provides continued evidence that ongoing natural attenuation processes are effectively controlling the further migration of the plume beyond its current limits. As indicated on Figures 2-1 and 2-2, plume boundary, landfill interior, and landfill perimeter monitoring data indicate that the dissolved phase plume is stable to decreasing in size. Recent total VOC concentrations for plume boundary monitoring wells (i.e., W-17S and W-18), offsite monitoring wells (i.e., W-20S), and landfill perimeter monitoring wells (i.e., W-6, W-7, W-13, PW-7, and PW-13) remain stable to decreasing when compared to historic data (Figure 2-1). In general, total VOC concentrations in mid-plume monitoring wells located furthest from the IRZ (i.e., W-16S, PW-3, PW-4, and PW-5) remain stable to decreasing (Figure 2-2). Total VOC concentrations at background monitoring well W-14S have also remained stable and are generally below the limits of detection.

As discussed in the Volatile Organic Compound Plume Delineation Report (ARCADIS 2011a), groundwater flow direction in the vicinity of monitoring well W-18 is generally to the south/southwest, toward the Susquehanna River and the mouth of the North Stream. The total VOC concentration detected in a groundwater sample collected from monitoring well W-18 in September 2011 was 22 micrograms per liter (µg/L). The VOCs detected in monitoring well W-18 were trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), 1,1,1-trichloroethane (1,1,1-TCA), and 1,1-dichloroethane (1,1-DCA). Delineation of the downgradient extent of the VOC plume (i.e., downgradient of monitoring well W-18) was completed in April 2011. Figure 2-2 shows the current extent of the plume. Groundwater quality data indicated that the component of groundwater flow discharging to the North Stream is not adversely impacted with VOCs, and that total VOC concentrations were generally below 5 µg/L. The VOC plume concentrations decrease along the groundwater flow path between monitoring well W-18 and the Susquehanna River, indicating that the VOC plume is attenuating prior to reaching the Susquehanna River. Comparison of Figures 2-1 and 2-2 corroborates this conclusion as evidenced by the decreasing size of the plume outside of the ARI and groundwater extraction system radii of influence.

2.4.2 Springs

As discussed in the Ecological Screening of Spring Water and Surface Water (ARCADIS 2010), a surface water sampling event was conducted between June 22 and 23, 2010. A total of three (3) samples were collected from the springs, and only six (6) VOCs were detected in spring water. All detected VOCs were below available freshwater criteria.

Most detected metals in springs along the embankment of the North stream were below relevant criteria. Exceedances of criteria were only noted for iron, manganese, and barium. Barium concentrations in spring and surface water samples ranged from 4.9 ug/L to 52.7 ug/L, which according to a USEPA Technical Factsheet on barium is well in the range of naturally occurring barium concentrations in surface waters throughout the United States.

2.4.3 Surface Water

In conjunction with the steadily improving spring water quality over time as the result of decreasing VOC concentrations in groundwater, surface water quality continues to maintain compliance with SW-SGVs, with VOC concentrations either not detected or the occurrence of sporadic trace detections. The data indicate that VOCs in groundwater undergo significant attenuation prior to reaching the North Stream, and VOCs that persist (i.e., detected in spring water) are rapidly attenuating in the North Stream through mixing and volatilization. Long-term sampling of the North Stream indicates that surface water quality is not being adversely impacted by the landfill.

A surface water sampling event was conducted between June 22 and 23, 2010. Surface water samples were collected as direct grab samples from the North Stream at areas co-located with the spring samples and at locations further downgradient of the springs (i.e., F-6 and F-8 locations). Concentrations of VOCs in surface water were below the limits of detection at all sampling locations with the exception of trace concentrations of 1,1-dichloroethane. This sampling event confirmed that no VOCs exceeded any of the SW-SGVs (ARCADIS 2010).

Surface water was also sampled in June 2010 for target analyte list (TAL) metals. All downstream samples collected from the North Stream had metals concentrations that were well below the applicable water quality criteria or appropriate screening benchmarks (ARCADIS 2010).

2.5 Summary of Dissolved Phase Plume Mass

To evaluate the performance of the existing remedy and the cost benefit of each of the four alternatives evaluated in Section 5.2, the initial (i.e., July 2002) and current (i.e., September 2011) amount of dissolved phase mass was calculated using the procedures outlined in Table A-7 (Appendix A). The plume area estimates were digitized from Figures 2-1 and 2-2. The residual contaminant mass beneath the landfill cap was not included in the calculations. Accordingly, these calculations represent treatment of the dissolved phase plume located downgradient of the landfill cap.

The initial dissolved phase plume mass (July 2002) was 34.8 pounds. Since July 2002, approximately twenty four (24) pounds (i.e., approximately 69%) of the initial mass have been removed through MNA and operation of the existing remedies. Evaluation of the current amount of dissolved phase mass in the plume indicates that, as of September 2011, approximately 10.8 pounds of mass remain and require treatment. This relatively small quantity of present-day dissolved-phase mass is consistent with the assessment that the overall groundwater remediation is in the latter stages of the remedial lifecycle.

2.6 Summary and Evaluation of Natural Attenuation

The following sections provide a summary of current and previous natural attenuation documentation and an overview of the calculation of estimated remedial timeframes. Estimated remedial timeframes were calculated for inclusion in remedial alternatives where applicable.

2.6.1 Summary of Current and Previous Natural Attenuation Documentation

Natural attenuation, or intrinsic remediation processes in groundwater were first investigated at the Site in June 1996 through the sampling and analysis of biogeochemical parameters along flowpaths toward the two major groundwater discharge boundaries (i.e., the North Stream and Susquehanna River). The objective of this study was to evaluate natural attenuation processes that were responsible for attenuation and mass reduction of VOCs in groundwater. The results of this evaluation are documented in Appendix A of the Revised Focus Feasibility Study (Geraghty & Miller 1996). To corroborate previous intrinsic remediation studies and conclusions and document the continued occurrence of these processes during the past ten (10) years, ARCADIS has prepared trend graphs illustrating the concentration trends of select VOC compounds with time for key monitoring wells at the downgradient plume boundary. Specifically, Figure 2-2 indicates that historic VOC concentrations at monitoring wells located at the plume toe (i.e., monitoring wells W-18, W-16S, W-20S, W-17S, and W-14S) have remained stable to decreasing. The data indicate that natural attenuation is occurring site wide since monitoring wells located outside of the ARI system radius of influence are exhibiting stable to decreasing contaminant concentrations. Additionally, as previously stated, comparison of VOC contours for baseline (Figure 2-1) and current (Figure 2-2) conditions indicate an overall decrease in plume size which further corroborates this conclusion.

2.6.2 Estimated Remedial Timeframe for Natural Attenuation

Existing historical data were used to estimate the remedial timeframe using naturally occurring attenuation methods at the Site (i.e., without operation of the existing groundwater extraction and ARI systems). Two evaluation methods were used to develop the estimated timeframe. The first method included calculation of the time it will take for clean water to flush from beneath the former source area (i.e., the landfill) downgradient to the plume toe. To complete this calculation, two sub-calculations were completed. First, the time for monitoring well GMMW-7 to achieve groundwater MCLs was estimated. Monitoring well GMMW-7 is located at the landfill boundary upgradient from the ARI system injection transect (see Figure 1-1). As shown on Figures 2-1 and 2-2, concentrations of contaminants at GMMW-7 show a declining trend, and total VOC concentrations have decreased by approximately fifty one (51) percent since the first sampling event in September 2005. Based on this concentration trend, the following can be concluded:

- Installation of the landfill cap in 1995 eliminated the landfill as a continuing source of contamination;

- The contaminants currently being detected at GMMW-7 are likely the result of residual contamination stored within aquifer storage zones (e.g., secondary porosity) beneath the landfill cap;

- Residual contamination in groundwater emanating from the landfill is naturally declining through a combination of processes such as biodegradation, dilution, dispersion, adsorption, and washout through the flushing action of clean water migrating from upgradient of the landfill.

Historical groundwater quality data at monitoring well GMMW-7 were used in a first order rate equation to calculate an overall natural degradation rate for each COC at this location (Table A-2, Appendix A). The overall degradation rate was then used to calculate a compound-specific half life for each COC, which was used to determine the time for current concentrations to eventually achieve groundwater MCLs. Refer to Table A-4 (Appendix A) for a summary of compound-specific natural degradation rates and half lives, and Table A-5 (Appendix A) for detailed remedial timeframe calculations. The results of this analysis show that vinyl chloride is the limiting compound, and it will take approximately thirty one (31) years to achieve groundwater MCLs at monitoring well GMMW-7.

The second sub-calculation determined the time it would take for the clean water at monitoring well GMMW-7, which occurs at year thirty one (31), to migrate downgradient to the plume toe. The location of the plume toe was estimated using data from the Volatile Organic Compound Plume Delineation Report (ARCADIS 2011a). The results of this analysis (Table A-5, Appendix A) show that it will require seventy two (72) years for the clean water front to reach the plume boundary, and a total of 103 years for contaminants at monitoring well GMMW-7 to reach groundwater MCLs and the clean water to migrate to the plume toe.

The second method evaluated was the site-wide rate at which contaminants naturally degrade as observed along the downgradient flow path of the plume. Monitoring wells W-5, GMMW-2, PW-4, and W-18 were selected to represent natural degradation along the downgradient flow path at the Site (see Figure 1-1 for monitoring well locations). Groundwater travel time to each monitoring well was calculated using the mass transport velocity. Pre-injection analytical data (collected in July 2002; Figure 2-1) were used to determine the overall site-wide attenuation rate for each contaminant of concern using a first order decay model (Table A-3, Appendix A). The site-wide attenuation rate for each COC was used to determine the time for current concentrations to reach groundwater MCLs. Refer to Table A-4 (Appendix A) for a summary of compound-specific natural degradation rates and half lives, and Table A-5 (Appendix A) for detailed remedial timeframe calculations. The results of this analysis show that cis-1,2-dichloroethene is the limiting compound for achieving groundwater MCLs at the site using this approach. Specifically, cis-1,2-dichloroethene concentrations will naturally degrade to below groundwater MCLs in approximately fifty nine (59) years.

Ultimately, the lesser of the two remedial timeframes will control the remedial timeframe for natural attenuation at the Site (i.e., whichever process occurs faster will drive the overall remedial timeframe). Comparison of the two methods indicates that the rate of site-wide attenuation controls the remedial timeframe. Therefore, it is estimated that groundwater MCLs will be attained at the Site in approximately fifty nine (59) years.

As shown in Table A-4 (Appendix A), each compound specific half life was compared to typical anaerobic half life values (Howard 1991). Overall, the site-specific rates calculated as part of the FFS evaluation are longer than the values specified in the literature, and represent a conservative approach to estimating the remedial timeframes. Nonetheless these values represent the most accurate estimate of remedial timeframes as they are based upon actual site data. The variation is likely attributable to the complex site-specific hydrogeologic framework described previously in this report.

3. Remedial Action Objectives

Remedial measures are based on attaining groundwater MCLs while mitigating potential exceedences of NYSDEC Ambient Water Quality Standards and Guidance Values (SW-SGVs) in the North Stream, a Class C water body (NYSDEC 1998), and potentially unacceptable risks to human health or ecological receptors from direct contact exposure to spring water along the North Stream. As stated in the ROD, the RAOs are as follows:

<u>Surface Water</u>

- Prevent exceedences of SW-SGVs for Site-related VOCs in the North Stream.

<u>Groundwater</u>

- Attain groundwater MCLs for Site-related VOCs in the glacial outwash aquifer; and
- Protect human health and the environment from current and potential future migration of contaminants in groundwater.

The ROD also identified soil and sediments as media of concern at the Site. However, the ROD Remedy addressed the RAOs for soil through the installation of a landfill cap which was completed in November 1995. The ROD Remedy addresses the RAOs for sediments through the SP-4 spring water remedy and use of existing engineering controls. Therefore, evaluating technologies to meet soil and sediments RAOs is not required.

4. Identification and Screening of Remedial Technologies

The purpose of this section is to identify and screen a range of remedial technologies to address groundwater. Selected technologies are developed into alternatives, which are then further evaluated during the detailed analysis of the remedial alternatives presented in Section 5 of this report. The identified technologies were screened using the following criteria:

- Effectiveness – Potential effectiveness in achieving RAOs; reliability of technology; and potential impacts to human health and the environment.

- Implementability – Technical and administrative feasibility of implementing the technology at the Site.

- Relative cost – Relative cost to implement the technology, including capital cost and cost for operation, maintenance, and monitoring (OM&M).

The remedial technologies that are part of the screening process include existing remedial technologies retained for analysis of alternatives and new remediation technologies/actions. These current and new technologies/actions, which are presented in Table 4-1, are as follows:

- Continued operation of the existing groundwater technologies/ remedial actions including:
    - Landfill cap (Section 2.3.2);
    - Groundwater extraction system (Section 2.3.3);
    - ERD (Section 2.3.4);
    - SP-5 spring water remediation system (Section 2.3.5);
    - SP-4 spring water remedy (Section 2.3.6);
    - Bedrock residential water supply wells (Section 2.3.7);
    - Institutional controls (Section 2.3.8);
    - Engineering controls (Section 2.3.9); and
    - Groundwater monitoring program (Section 2.3.10).

- Modified groundwater monitoring and surface water and spring water sampling;

- Additional deed restrictions on groundwater use (i.e., USEPA-mandated groundwater use restrictions on private parcels [Section 2.3.8]).

- Additional engineering controls or inspections including the routine inspections and certification of bedrock residential supply wells; and,

- Natural attenuation.

5. Development and Analysis of Remedial Alternatives

The following sections provide a description and comparative discussion of the remedial alternatives developed using the technologies retained in Section 4. A brief summary of the evaluation criteria used to develop and evaluate each alternative is also provided.

5.1 Evaluation Criteria

As outlined in Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988), the detailed analysis of alternatives is the analysis and presentation of the relevant information needed to allow decision-makers to select remedies for impacted environmental media. During a detailed analysis, each alternative is assessed against nine evaluation criteria pursuant to Section 300.430(e)(9)(iii) of the NCP.

The detailed evaluation of remedial alternatives was performed using the following criteria. Each criterion is discussed in further detail in the following subsections:

- Overall protection of public health and environment.

- Compliance with applicable or relevant and appropriate requirements (ARARs).

- Long term effectiveness and permanence.

- Reduction of toxicity, mobility, or volume through treatment.

- Short term effectiveness.

- Implementability.

- Cost.

- Regulatory acceptance.

- Community acceptance.

The first two criteria relate directly to statutory findings that must be made as part of a ROD. For this reason, they are categorized as threshold criteria with which each alternative must comply. The next five criteria are commonly referred to as the primary balancing criteria. These seven criteria are further described in this section and make up the major portion of the analysis. The remaining two criteria, state and community acceptance, are commonly referred to as modifying criteria. These criteria are typically evaluated at a later stage, after comments have been received by the state and the community. The criteria will be addressed at that time.

The seven criteria are evaluated based on USEPA guidance as to whether the RAOs are adequately addressed, and the criteria are screened as favorable, moderately favorable, or unfavorable. Favorable is a medium-specific term indicating an acceptable level of satisfaction of goals. Moderately favorable is a medium-specific term indicating an acceptable level of satisfaction of goals, but other alternatives may address the goal more effectively. Unfavorable is a medium-specific term indicating the alternative does not address the goal adequately. A detailed description of the seven criteria evaluated is summarized in Table 5-1.

5.2 Description and Analysis of Alternatives

Four remedial alternatives were developed for evaluation and comparison using the retained technologies and are included in this FFS. The following sections describe the development rationale of the alternative and its primary components. The remedial alternatives are evaluated against each of the seven criteria discussed in Section 5.1. This information is summarized in Table 5-2.

A fifth remedial alternative was also developed and evaluated to determine if a more aggressive remedial strategy could reduce the remedial timeframe in a cost effective manner. The fifth alternative incorporated the installation of multiple additional injection transects located downgradient of the existing ARI system injection wells. The fifth remedial alternative was excluded from further evaluation and inclusion in this report for the following reasons:

- As stated in Section 2.5.2, it will take 31 years for groundwater to achieve MCLs beneath the existing landfill cap. Accordingly, the shortest time duration that MCLs can be achieved on a site-wide basis is 31 years. Providing additional transects downgradient will not accelerate the site-wide remedial timeframe.

- The estimated cost to implement the fifth remedial alternative was greater than the cost for Alternative 4.

- The optimal locations for additional transects do not fall on Broome County owned property. As such, implementation of the fifth alternative is likely infeasible (i.e., it will not be feasible to obtain access for the additional remediation infrastructure on private parcels).

In summary, the fifth alternative provided no remedial or financial benefit and was determined to be technically infeasible to be implemented.

5.2.1 Alternative 1 – No Action

Alternative 1 consists of the following:

- Discontinued operation of the existing groundwater extraction, ARI, and SP-5 remediation systems;

- Discontinued implementation of the existing engineering controls (Section 2.3.9) and institutional controls (Section 2.3.8) and groundwater monitoring (Section 2.3.10).

Alternative 1 was evaluated to provide a baseline to compare Alternatives 2 through 4. Alternative 1 will require a time period of approximately fifty nine (59) years to attain MCLs (Appendix A Table A-5).

A summary of Alternative 1 evaluated against the seven evaluation criteria outlined in Section 5.2 is provided in Table 5-2. In summary, Alternative 1 is unfavorable when evaluated against four (4) of the seven (7) evaluation criteria, including protection of public health and the environment, compliance with MCLs, long term effectiveness and permanence, and short term impacts and effectiveness. The use of institutional controls (Section 2.3.8), engineering controls such as physical inspections of residential water supply wells, and implementation of a groundwater monitoring program is required to ensure compliance with these criteria. Alternative 1 is the most favorable with respect to the cost criteria; however, because Alternative 1 does not satisfy the protection of public health and the environment criteria, it is not considered a favorable alternative.

5.2.2 Alternative 2 – Monitored Natural Attenuation and Engineering and Institutional Controls until Groundwater MCLs are Achieved (Approximately Fifty Nine (59) Years)

Alternative 2 consists of discontinuing operation of the existing groundwater extraction system and the existing ARI system. Engineering controls and institutional controls would be implemented as described below. COC mass removal from groundwater in the glacial outwash aquifer would be achieved through natural attenuation.

The following major components are considered part of Alternative 2:

- Discontinued operation of the existing groundwater extraction and ARI remediation systems;
- Groundwater remediation through monitored natural attenuation (MNA);
- Continued operation of the existing SP-5 remediation system for twenty one (21) years (estimated time for clean water front to reach SP-5; refer to Appendix A Table A-6);
- Continued implementation of existing engineering controls (Section 2.3.9);:
- Continued implementation of existing institutional controls (Section 2.3.8);
- Implementation of the additional institutional and engineering controls (Section 4.0).
- Implementation of MNA through a revised groundwater monitoring program.

As referenced previously, institutional controls would consist of existing deed restrictions on Broome County owned property and USEPA-mandated groundwater use restrictions on private parcels that would prohibit the installation and use of groundwater supply wells in the glacial outwash aquifer (Section 2.3.8). Engineering controls would include inspections of the North Stream and SP-4 remedy on an as-needed basis, and routine inspections and certification of the landfill cap. Additional engineering controls to be emplaced include routine, physical inspections and certification of residential water supply wells to ensure proper operation and use. A revised groundwater monitoring program will continue to document and confirm ongoing MNA processes and confirm that the plume is stable to declining.

Data to support discontinuing operation of the existing groundwater extraction system and the existing ARI system are discussed in Sections 2.3.11.2 and 2.3.11.3, respectively. Data to support the occurrence and use of MNA as a remedial approach are provided in Section 2.5. Similar to Alternative 1, Alternative 2 will require a time period of approximately fifty nine (59) years to attain groundwater MCLs as the remedial timeframe is driven by the rate of site-wide attenuation. The majority (approximately 68%) of the mass remaining in the dissolved phase plume (Section 2.2.1) will be removed by MNA (7.3 of the 10.8 total pounds; refer to Tables A-7 and A-8 for detailed calculations). The remaining mass (approximately 32%) will be removed through operation of the SP-5 remediation system.

A summary of Alternative 2 evaluated against the seven evaluation criteria outlined in Section 5.2 is provided in Table 5-2. Alternative 2 is considered a "favorable" alternative when evaluated against five of the seven evaluation criteria, including overall protectiveness of public health and the environment, long term effectiveness and permanence, short term impacts and effectiveness, implementability, and cost. Alternative 2 is considered a "moderately favorable" alternative when evaluated against the compliance with ARARs and reduction of toxicity, mobility, or volume of contamination through treatment evaluation criteria. Alternative 2 is identical to Alternative 1 except that the use of institutional controls and engineering controls (as described above), will ensure compliance with the protection of public health criteria. Alternative 2 is not as favorable as Alternatives 3 and 4 when evaluated against the reduction of toxicity, mobility, or volume of contamination through treatment evaluation criteria because it requires the longest remedial timeframe. Alternatives 3 and 4 decrease the remedial timeframe by approximately (37) thirty-seven percent when compared to Alternative 2. However, Alternative 2 is the most favorable with respect to the cost criteria when compared to Alternatives 3 and 4. The total cost for Alternative 2 is approximately sixty (60) percent less than for Alternative 3 and sixty six (66) percent less than for Alternative 4.

Overall, Alternative 2 is considered a favorable alternative. Alternative 2 will achieve groundwater MCLs in a timeframe comparable to Alternatives 3 and 4 at a lower cost and with less energy and resource use (e.g., is more favorable accordance with green practices for remediation).

5.2.3 Alternative 3 – Operation of the Existing ARI System until Groundwater MCLs are Achieved (Approximately Thirty Seven (37) Years) and Engineering and Institutional Controls

Alternative 3 consists of discontinuing operation of the existing groundwater extraction system and continuing to operate the existing ARI system until MCLs are achieved. Existing engineering controls and institutional controls would continue to be implemented, as described below. COC mass removal from groundwater in the glacial outwash aquifer would be achieved through continued operation of the ARI system and natural attenuation processes.

The following major components are considered part of Alternative 3:

- Discontinued operation of the existing groundwater extraction remediation system;
- Continued operation of the existing ARI system;
- Continued operation of the existing SP-5 remediation system for twenty one (21) years (estimated time for clean water front to reach SP-5; refer to Appendix A Table A-6);
- Continued implementation of the following existing engineering controls (Section 2.3.9):
    - Landfill cap;
    - Bedrock residential water supply wells.
- Implementation of the additional institutional and engineering controls (Section 4.0).
- Continued implementation of existing institutional controls (Section 2.3.8); and
- Implementation of MNA through a revised groundwater monitoring program.

As referenced previously, institutional controls would consist of existing deed restrictions on Broome County owned property and USEPA-mandated groundwater use restrictions on private parcels that would prohibit the installation and use of groundwater supply wells in the glacial outwash aquifer (Section 2.3.8). Engineering controls would include routine, physical inspections of the North Stream and SP-4 remedy on an as-needed basis, and, routine inspections and certification of the landfill cap. Additional engineering controls to be emplaced include routine, physical inspections and certification of residential water supply wells to ensure proper operation and use. A revised groundwater monitoring program will continue to document and confirm ongoing ARI system operation and/or MNA processes and confirm that the plume is stable to declining.

Similar to Alternative 2, data to support discontinuing operation of the existing groundwater extraction system is discussed in Sections 2.3.11.2 and 2.3.11.3, respectively. Alternative 3 will require a time period of approximately thirty seven (37) years to attain groundwater MCLs as the remedial timeframe is driven by the rate of site-wide attenuation. The majority (approximately 69%) of the baseline plume mass (Section 2.2.1) will be removed by active remediation (7.5 of the 10.8 total pounds; refer to Tables A-7 and A-8 for detailed calculations). The remaining mass will be removed through MNA. Operation of the existing ARI system will increase the mass removed through active remediation by approximately four (4) pounds of mass (i.e., by approximately 0.14 pounds per year). This insignificant increase in the mass removal rate does not outweigh the additional costs (approximately $101,054 per pound; Table A-8 Appendix A) incurred from operation of the ARI system. As discussed in Section 2.5, approximately sixty nine (69) percent of the initial plume mass was removed during the first nine (9) years of system operation. Under Alternative 3, the remaining thirty one (31) percent of the plume mass will be removed over a thirty seven (37)-year operational period, which further corroborates that the ARI system will provide no additional benefit to expediting mass removal.

Alternative 3 requires operation of the existing ARI system until contaminant concentrations throughout the Site reach MCLs. The MNA operating period was calculated using an iterative process to determine when contaminant concentrations at an estimated future location of the clean water front will naturally degrade to MCLs by the time the clean water front reaches that location. The time for contaminant concentrations to reach MCLs was calculated using the same approach described in Section 2.5; however, the initial concentration was based on an average of analytical results from samples collected from monitoring wells PW-4 and W-18 and recovery well GMPW-4 (Table A-5 Appendix A) over the past five years of system operation. These data represent the estimated current concentration at the location of the clean water front after thirty seven (37) years of operation. Site-wide attenuation rates of MNA (Appendix A Table A-3) were assumed for each contaminant because the estimated location of the clean water front is outside of the ARI system area of influence. Alternative 3 will require a total time period of approximately thirty seven (37) years to attain MCLs. The time required for monitoring well GMMW-7 concentrations to naturally degrade to below MCLs is not included in the clean water front calculation under this alternative because contaminant concentrations emanating from beneath the landfill will be addressed by operation of the ARI system as they travel downgradient.

A summary of Alternative 3 evaluated against the seven evaluation criteria outlined in Section 5.2 is provided in Table 5-2. Alternative 3 is considered a “favorable” alternative when evaluated against five of the seven evaluation criteria, including overall protectiveness of public health and the environment, long term effectiveness and permanence, short term impacts and effectiveness, implementability, and reduction of toxicity, mobility, or volume of contamination through treatment. Alternative 3 is considered a “moderately favorable” alternative when evaluated against the compliance with ARARs evaluation criteria and an “unfavorable” alternative when evaluated against the cost criteria. Alternative 3 is identical to Alternative 4 when evaluated against all evaluation criteria except for cost. Alternative 3 is the second most costly alternative. The total cost for Alternative 3 is approximately fourteen (14) percent less than for Alternative 4, but is approximately sixty (60) percent greater than for Alternative 2.

Overall, Alternative 3 is considered a moderately favorable alternative. Alternative 3 will achieve groundwater MCLs in a shorter timeframe than Alternatives 1 and 2 but at a significantly higher cost. There is no significant benefit to the remedial timeframe or to protection of human health and the environment from operating the ARI system.

5.2.4 Alternative 4 – No Further Action/Continued Operation of the Existing Remedies until Groundwater MCLs are Achieved (Approximately Thirty Seven (37) Years)

Alternative 4 consists of continuing operation of the existing groundwater extraction and ARI systems until MCLs are achieved. Existing engineering controls and institutional controls would continue to be implemented, as described below. COC mass removal from groundwater in the glacial outwash aquifer would be achieved through continued operation of the groundwater extraction and ARI systems. Remediation and monitoring activities are currently being conducted pursuant to the ROD issued in March 1991 (USEPA 1991) and ESDs that were issued in September 2000 and July 2004.

The following major components are considered part of Alternative 4:

- Continued operation of the existing groundwater extraction remediation system;
- Continued operation of the existing ARI system;
- Continued operation of the existing SP-5 remediation system for twenty one (21) years (estimated time for clean water front to reach SP-5; refer to Appendix A Table A-6);
- Continued implementation of the following existing engineering controls (Section 2.3.9):
  - Landfill cap;
  - Bedrock residential water supply wells.
- Implementation of additional institutional and engineering controls (Section 4.0).
- Continued implementation of existing institutional controls (Section 2.3.8); and
- Implementation of MNA through a revised groundwater monitoring program.

As referenced previously, institutional controls would consist of existing deed restrictions on Broome County owned property and USEPA-mandated groundwater use restrictions on private parcels that would prohibit the installation and use of groundwater supply wells in the glacial outwash aquifer (Section 2.3.8). Engineering controls would include inspections of the North Stream and SP-4 remedy on an as-needed basis, and, routine inspections and certification of the landfill cap. Additional engineering controls to be emplaced include routine, physical inspections and certification of residential water supply wells to ensure proper operation and use. A revised groundwater monitoring program will continue to document and confirm ongoing groundwater extraction and ARI system operation and/or MNA processes and confirm that the plume is stable to declining.

Alternative 4 will require a time period of approximately thirty seven (37) years to attain groundwater MCLs as the remedial timeframe is driven by the rate of site-wide attenuation.

Alternative 4 requires operation of the existing groundwater extraction and ARI systems until contaminant concentrations throughout the Site reach MCLs. The operating period was calculated using the same approach described for Alternative 3. Similar to Alternative 3, Alternative 4 will require a total time period of approximately thirty seven (37) years to attain MCLs because groundwater extraction provides no additional benefit to mass removal. The time required for monitoring well GMMW-7 concentrations to naturally degrade to below MCLs is not included in the clean water front calculation under this alternative because contaminant concentrations emanating from beneath the landfill will be addressed by operation of the ARI system as they travel downgradient. The majority (approximately 78%) of the baseline plume mass (Section 2.2.1) will be removed by active remediation (8.4 of the 10.8 total pounds; refer to Tables A-7 and A-8 for detailed calculations). The remaining mass will be removed through MNA. Operation of the existing groundwater extraction and ARI systems will increase the mass removed through active remediation by approximately 4.9 pounds of mass (i.e., by approximately 0.17 pounds per year) when compared to Alternative 2. Operation of the existing groundwater extraction system will increase the mass removed through active remediation by approximately 0.9 pounds of mass (i.e., by approximately 0.03 pounds per year) when compared to Alternative 3. This insignificant increase in the mass removal rate does not outweigh the additional costs (approximately $126,901 per pound; Table A-8 Appendix A) incurred from operation of the ARI and groundwater extraction systems. As discussed in Section 2.5, approximately sixty nine (69) percent of the initial plume mass was removed during the first nine (9) years of system operation. Under Alternative 4, the remaining thirty one (31) percent of the plume mass will be removed over a thirty seven (37)-year operational period, which further corroborates that the groundwater extraction and ARI systems will provide no additional benefit to expediting mass removal.

A summary of Alternative 4 evaluated against the seven evaluation criteria outlined in Section 5.2 is provided in Table 5-2. Alternative 4 is considered a “favorable” alternative when evaluated against five of the seven evaluation criteria, including overall protectiveness of public health and the environment, long term effectiveness and permanence, short term impacts and effectiveness, implementability, and reduction of toxicity, mobility, or volume of contamination through treatment. Alternative 4 is considered a “moderately favorable” alternative when evaluated against the compliance with ARARs evaluation criteria and an “unfavorable” alternative when evaluated against the cost criteria. Alternative 4 is identical to Alternative 3 when evaluated against all evaluation criteria except for cost. Alternative 4 is the most costly alternative. The total cost for Alternative 4 is approximately sixty six (66) percent greater than for Alternative 2 and approximately fourteen (14) percent greater than for Alternative 3.

Overall, Alternative 4 is considered an unfavorable alternative. Alternative 4 will achieve groundwater MCLs in a shorter timeframe than Alternatives 1 and 2, but at a significantly higher cost. There is no significant benefit to the remedial timeframe or to protection of human health and the environment from operating the ARI system or groundwater extraction system.

6. Recommended Remedy

Summary of Recommended Remedial Alternative

Based on the analyses conducted in this FFS, Broome County's recommended remedy is Alternative 2. Under Alternative 2, VOC-impacted groundwater is remediated using MNA as the primary remedial technology. A revised monitoring program would be implemented for the entire fifty nine (59) year period. As discussed previously, Alternative 2 consists of the following major components:

- Discontinued operation of the existing groundwater extraction and ARI remediation systems;
- Groundwater remediation through MNA;
- Continued operation of the existing SP-5 remediation system until influent data fall below effluent Model Technology BPJ Limits recommended for carbon adsorption with appropriate pretreatment (Attachment C of TOGS 1.2.1). For the purposes of this FFS, this is estimated to occur when the clean water front reaches SP-5, or after twenty one (21) years (Appendix A Table A-6);
- Continued implementation of existing engineering and institutional controls;
- Implementation of additional engineering and institutional controls (Section 4.0); and
- Implementation of MNA through a revised groundwater monitoring program.

Rationale for selection of the recommended remedy is provided in Table 6-1. As presented in the table, the recommended remedy achieves the following RAOs and selection criteria:

- Achieves protection of public health through the use of institutional controls and engineering controls.

- Remedy will achieve RAOs at the Site in approximately fifty nine (59) years, which is not significantly greater than the timeframes calculated for Alternatives 3, 4.

- Achieves short-term and long-term effectiveness by leaving no significant risks to the public or the environment through use of proven, reliable remedial technologies and appropriate engineering and institutional controls.

- Reduces mobility and volume of VOCs at the Site through natural attenuation processes. As shown in Table A-8, operation of the existing groundwater extraction system and ARI system will not expedite the rate of reduction of VOC volume in a cost effective manner.

- Cost effective approach to meeting RAOs and achieving a comprehensive solution to VOCs in groundwater. As shown in Table A-8, operation of the existing ARI system and existing groundwater extraction system is not cost effective.

Alternative 2 is implementable and in compliance with the NCP. Alternative 2 is comparable to Alternatives 3 and 4 for all evaluation criteria, and is the most cost-effective of the four alternatives. It has been determined that the groundwater extraction and treatment and ARI system remedies are unwarranted, not cost-effective, and provide little additional benefit to the current remedy under the criteria established by the NCP based on information obtained, evaluations conducted, and conditions/circumstances that have changed since the ROD was issued, which include:

- Evaluation of historical data indicates that the rate at which contaminant mass is transported downgradient of the landfill is significantly slower than estimated in the original CSM. This slower rate of mass transport triggered a re-evaluation of the originally estimated remedial timeframes, the results of which indicated that the active remedy components provide little additional benefit to the volume of mass removed and to the overall remedial timeframe.

- Accordingly, revised calculations indicate that MNA will be the primary driver for achieving groundwater MCLs, even with continued operation of the current remedy.

- Water quality data indicating that the areal extent of VOC-impacted groundwater in the glacial outwash aquifer is static and total VOC concentrations are generally stable to decreasing over time as evidenced by historical analytical results from landfill interior, landfill perimeter, downgradient and plume boundary monitoring well data.

- Landfill capping (completed in November 1995) has eliminated the landfill as a source of VOC contamination and continues to improve water quality, as evidenced by the decreasing VOC concentration trend at monitoring well GMMW-7.

- Elimination of drinking water receptors of VOC-impacted groundwater in the glacial outwash aquifer through the use of deed restrictions and installation of bedrock supply wells on adjacent properties.

- Continued compliance with NYSDEC SW-SGVs in the North Stream.

- No unacceptable risk to human health and the environment associated with COCs in the North Stream.

- Mitigation of the presence of tailwater and successful operation of the SP-5 remediation system.

- In addition to the above regulatory-driven selection criteria, Broome County promotes alternatives that conserve limited energy and other resources and will continue to evaluate use of sustainable practices. Alternative 2 represents the most favorable alternative in terms of limiting energy and resource use in the interest of promoting “green” technologies.

In light of the stable to decreasing areal extent of the plume, decreasing VOC concentrations, projections for continued improvement, and unfavorable costs with no significant remedial benefit associated with groundwater extraction and treatment and ARI system groundwater treatment, Alternative 2 is implementable and in compliance with the NCP, and is more favorable than the current Remedy.

7. References

ARCADIS G&M, Inc. 2002. Long-Term Monitoring Plan, Colesville Landfill, Broome County, New York, NYSDEC Site 704010. June 28, 2002.

ARCADIS G&M, Inc. 2003. Long-Term Monitoring Plan Addendum for Spring Water Remediation Systems, Colesville Landfill, Broome County, New York, NYSDEC Site 704010. November 3, 2003.

ARCADIS G&M, Inc. 2004. Interim Remedial Action Report, Colesville Landfill, Broome County, New York, NYSDEC Site 704010. September 22, 2004.

ARCADIS G&M, Inc. 2005 Proposed Modifications to Long-Term Monitoring Program, Broome County, New York, NYSDEC Site 704010. June 28, 2005.

ARCADIS G&M, Inc. 2006. Hydraulic Injection Test and Alternate Electron Donor Pilot Test, Colesville Landfill, Broome County, New York (Site No. 704010). November 30, 2006.

ARCADIS 2010. Ecological Screening of Spring Water and Surface Water, Colesville Landfill, Broome County, New York, NYSDEC Site 704010. October 1, 2010.

ARCADIS 2011a. Volatile Organic Compound Plume Delineation Report, Colesville Landfill, Broome County, New York, NYSDEC Site 704010. March 18, 2011.

ARCADIS 2011b. Operational Year 8 Annual Monitoring Report, Colesville Landfill, Broome County, New York, NYSDEC Site 704010. April 26, 2011.

Driscoll, F. G. 1986. Groundwater and Wells. Saint Paul, Minnesota, Johnson Division.

Geraghty & Miller, Inc. 1996. Revised Focused Feasibility Study, Colesville Landfill, Colesville, New York. October 19, 1996.

Howard, P.H. and R.S. Boethling et al. 1991. Handbook of Environmental Degradation Rates. Chelsea, Michigan, Lewis Publishers.

New York State Department of Environmental Conservation (NYSDEC) 1998. Division of Water Technical and Operational Guidance Series 1.1.1, Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations. Reissue

Date, June 1998.Payne, F.C. and J.A. Quinnan et al. 2008. Remediation Hydraulics. Boca Raton, Florida, CRC Press.

Wehran-New York, Inc. 1988. Colesville Landfill Remedial Investigation Report. September 1988.

United States Environmental Protection Agency (USEPA) 1988. Draft Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA.

USEPA 1991. Record of Decision, Colesville Landfill, Broome County, New York. NYSDEC Site 704010. 1991.

Table 4-1. Screening of Remedial Technologies, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

General Response Action	Remedial Technology Type	Process Options	Technology Description	Effectiveness	Implementability	Relative Cost	Favorable, Moderately Favorable, Unfavorable
Continue Operation of Existing Remedy	Groundwater Extraction	Extraction Wells	Groundwater pumped from vertical extraction wells and conveyed to ex-situ treatment system.	Site geology does not allow for efficient extraction of groundwater. The amount of mass removed through groundwater extraction is negligible.	Already implemented; However; would require a significant well infrastructure upgrade to provide any meaningful reduction in the overall site remedial timeframe.	Very High	Unfavorable
	In-Situ Groundwater Treatment	Enhanced Biodegradation	Organic substrate injected into groundwater to stimulate existing microbial communities that degrade VOCs through reductive dechlorination.	Conventional technology to treat VOCs in groundwater; Already proven effective at the site.	Already implemented; However; would require a significant well infrastructure upgrade to provide any meaningful reduction in the overall site remedial timeframe.	Moderate to High	Moderately Favorable
	Spring Water Treatment	Adsorption	Liquid phase granular activated carbon (LPGAC) used to remove VOCs from spring water at existing spring SP-5.	Conventional technology to treat VOCs in spring water. Proven effective at existing spring SP-5.	Already implemented.	Low	Favorable
	Groundwater Monitoring	Groundwater monitoring can be used alone or in conjunction with other remedial technologies and/or engineering controls.	Existing monitoring wells (see Figure 2) are used to collect groundwater samples to document levels of impact to the groundwater at the Site and to track COC migration.	Does not achieve ARARs, but can be used in conjunction with other remedial technologies and/or engineering controls to ensure protection of human health and the environment.	Already implemented.	Low	Favorable
	Surface Water and Spring Water Sampling	Surface water and spring water sampling can be used alone or in conjunction with other technologies.	Surface water and spring water samples are collected at predetermined locations along the North Stream (see Figure 2) to provide information that indicates the levels of impact associated with COCs in the North Stream.	Does not achieve ARARs, but can be used in conjunction with other remedial technologies and/or engineering controls to ensure protection of human health and the environment.	Already implemented.	Low	Favorable
	Engineering Inspections	Engineering inspections can be used alone or in conjunction with other technologies.	Visual inspections of site conditions are completed to ensure existing remedy components necessary for the protection of human health and the environment remain in place and effective. Inspections also evaluate for new and changing site conditions that could adversely affect operation of existing remedy components.	Does not achieve ARARs, but can be used in conjunction with other remedial technologies and/or engineering controls to ensure protection of human health and the environment.	Already implemented.	Low	Favorable
	Deed Restrictions on Groundwater and Surface Water Use	Deed restrictions can be used alone or in conjunction with other technologies.	Deed restrictions or local zoning restrictions are imposed.	Restrictions have been proven effective in minimizing contact with impacted media.	Implementable; Some restrictions have already been implemented. Restrictions may become administratively burdensome to implement.	Low to Moderate	Favorable

See notes on last page.

Table 4-1. Screening of Remedial Technologies, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

General Response Action	Remedial Technology Type	Process Options	Technology Description	Effectiveness	Implementability	Relative Cost	Favorable, Moderately Favorable, Unfavorable
Institutional Controls and Monitoring	Revised Groundwater Monitoring Program	Groundwater monitoring can be used alone or in conjunction with other remedial technologies and/or engineering controls.	Existing monitoring wells (see Figure 2) used to collect groundwater samples to document levels of impact to the groundwater at the Site and to track COC migration.	Does not achieve ARARs, but can be used in conjunction with other remedial technologies and/or engineering controls to ensure protection of human health and the environment.	Implementable	Low	Favorable
In-Situ Treatment	In-Situ Groundwater Treatment	In-Situ Chemical Oxidation (ISCO)	Chemical oxidant injected into groundwater to break down VOCs into non-toxic compounds. Requires direct contact of oxidants with target compounds.	Conventional technology to treat VOCs in groundwater; however, will have limited effectiveness at the site due to site hydrology. Specifically, existing storage zones within the aquifer (i.e., clays, silts, immobile porosity zones) will prevent the direct contact of oxidant with target compounds.	Implementable; Difficult to implement. Requires numerous injection and monitoring wells. Requires a significant volume of oxidant which will result in storage, handling, and transfer of hazardous materials.	Very High	Unfavorable
		Zero-Valent Iron Permeable Reactive Barrier	Zero-valent iron media is installed through trenching or other means as a vertical barrier oriented perpendicular to the direction of groundwater flow. The zero-valent iron degrades chlorinated VOCs through abiotic reductive dehalogenation to harmless end products.	Conventional technology to treat VOCs in groundwater.	Implementable; However; would require multiple barrier installations to provide any meaningful reduction in overall site remedial timeframe. Will require special equipment/ installation techniques to install a barrier near the landfill perimeter due to the depth of contamination. Will require a significant quantity of zero-valent iron due to vertical thickness and length of each barrier.	Very High	Unfavorable - provides no additional benefit over the existing reductive dechlorination technology implemented at the site (ERD) and is significantly more cost prohibitive.
		Air Sparging	Air is injected into groundwater enabling the transfer of dissolved phase VOCs into the vapor phase. Volatilized VOCs are captured by a vapor extraction system for treatment prior to discharge to the atmosphere.	Conventional technology to treat VOCs in groundwater; however, will have limited effectiveness at the site due to site hydrology. Specifically, existing storage zones within the aquifer (i.e., clays, silts, immobile porosity zones) will prevent the direct contact of air with target compounds.	Likely would generate uncontrolled VOC vapors in subsurface soils. Would require significant well infrastructure.	Very High	Unfavorable
		In-Well Air Stripping	Air lift pumping used to volatilize VOCs from groundwater to the vapor phase. Pumped/partially treated water is discharged to an upper screen interval where a portion is re-circulated to the lower screen, as required, to meet RAOs. Off-gas is collected and treated through a variety of treatment methods.	Effectiveness is diminished by the presence of clay layers or variations in permeability that reduce stripping efficiency, cause uncontrolled migration of contaminants, and prevent reinjection of groundwater.	Difficult to implement; requires numerous remedial wells and associated infrastructure.	Very High	Unfavorable

See notes on last page.

Table 4-1. Screening of Remedial Technologies, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

General Response Action	Remedial Technology Type	Process Options	Technology Description	Effectiveness	Implementability	Relative Cost	Favorable, Moderately Favorable, Unfavorable
In-Situ Treatment Continued	In-Situ Groundwater Treatment Continued	Natural Attenuation	Naturally occurring processes (e.g., dilution, dispersion, sorption, biodegradation) attenuate low concentrations of contaminants.	Site-related groundwater contaminants treatable by natural attenuation processes. Natural/existing site geochemistry is reductive and conducive for natural attenuation of chlorinated VOCs.	Implementable; Readily implementable; no construction required, except for additional monitoring well installation, as necessary.	Low	Favorable

Notes:

ARAR Applicable and relevant or appropriate requirements.
ARI Automated reagent injection.
COC Contaminant of concern.
NYSDEC New York State Department of Environmental Conservation.
O&M Operation and maintenance.
RAOs Remedial action objectives.
VOC Volatile organic compounds.

Table 5-1. Evaluation Criteria for Remedial Alternatives, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Evaluation Criteria	**Criteria Definition**
Overall Protection of Public Health and the Environment	Ability to protect public health and the environment, assessing how risks posed by existing and potential exposure pathways are eliminated or reduced, through removal, treatment, engineering controls, or institutional controls. Ability to achieve the RAOs is also evaluated.
Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)	Ability to meet requirements of environmental laws, regulations, standards and guidance. If one or more ARARs are not met upon implementation of a remedial alternative, evaluation of whether a waiver is required is provided.
Long Term Effectiveness and Permanence	If wastes or residuals will remain at the site after implementation, then the following are evaluated: (1) the magnitude and nature of the residual risks posed by the remaining wastes; (2) the adequacy of the controls intended to limit the risks; (3) the reliability of these controls; and (4) the ability of the remedy to continue to meet the RAOs in the future.
Reduction of Toxicity, Mobility, or Volume through Treatment	Ability of an alternative to permanently and significantly reduce toxicity, mobility or volume of the wastes.
Short Term Effectiveness	Potential short-term impacts of a remedial action upon the community, the site workers, and the environment. The period of time required to achieve RAOs is estimated.
Implementability	The technical and administrative feasibility of implementing a remedial alternative. For technical feasibility, the difficulties associated with the construction and operation of the alternative and the ability to monitor the effectiveness of the remedy are evaluated. For administrative feasibility, the availability of the necessary personnel and material is evaluated, along with the difficulties in obtaining permits, rights-of-way, and site access.
Cost	Capital costs and O&M costs are estimated on a present worth basis. Although cost is the last criterion evaluated, where two or more alternatives have satisfied the other evaluation criteria, cost effectiveness should be used as the basis for final remedy selection.

See notes on last page.

Table 5-1. Evaluation Criteria for Remedial Alternatives, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Definitions

O&M	Operation and maintenance.
RAOs	Remedial Action Objectives.

Table 5-2. Detailed Evaluation of Remedial Alternatives, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Alternatives	ALTERNATIVE 1 No Action	ALTERNATIVE 2 Monitored Natural Attenuation and Engineering and Institutional Controls until MCLs are Achieved (Approximately Fifty Nine (59) Years)	ALTERNATIVE 3 Operation of the Existing ARI System until Groundwater MCLs are Achieved (Approximately Thirty Seven (37) Years) and Engineering and Institutional Controls	ALTERNATIVE 4 No Further Action/Continued Operation of the Existing Remedies until MCLs are Achieved (Approximately Thirty Seven (37) Years)
Alternative Description	- Discontinue operation of the existing landfill cap, groundwater extraction, ARI, and SP-5 remediation systems and SP-4 spring remedy. - Discontinue implementation of existing institutional controls (Section 2.3.8) and engineering controls (Section 2.3.9) and groundwater monitoring.	- Discontinue operation of the existing groundwater extraction and ARI remediation systems. - Continue operation of the existing SP-5 remediation system for 21-years (time for clean water front to reach SP-5; Appendix A-6). - Continue implementation of current SP-4 spring water remediation system. - Continue implementation of existing institutional controls (Section 2.3.8). - Continue implementation of existing engineering controls (Section 2.3.9). - Implement additional institutional and engineering controls (Section 4). - Implement MNA through a revised groundwater monitoring program until MCLs are achieved (approximately 59-years).	- Discontinue operation of the existing groundwater extraction system and operate the existing ARI system until MCLs are achieved (approximately 37-years). - Continue operation of the existing SP-5 remediation system for 21-years (time for clean water front to reach SP-5; Appendix A-6). - Continue implementation of current SP-4 spring water remediation system. - Continue implementation of current institutional controls (Section 2.3.8). - Continue implementation of existing engineering controls (Section 2.3.9). - Implement additional institutional and engineering controls (Section 4). - Implement a revised groundwater monitoring program until MCLs are achieved (approximately 37-years).	- Continue operation of the existing groundwater extraction system and ARI system until MCLs are achieved (approximately 37-years). - Continue operation of the existing SP-5 remediation system for 21-years (time for clean water front to reach SP-5; Appendix A-6). - Continue implementation of current SP-4 spring water remediation system. - Continue implementation of current institutional controls (Section 2.3.8). - Continue implementation of existing engineering controls (Section 2.3.9). - Implement additional institutional and engineering controls (Section 4). - Implement a revised groundwater monitoring program until MCLs are achieved (approximately 37-years).
Overall Protectiveness of Public Health and the Environment	Not protective of human health and the environment. Institutional controls are required for protection of human health and the environment. Not Favorable.	Protective of human health and the environment through engineering and institutional controls and groundwater monitoring. Remedy will achieve MCLs within approximately 59-years.' Favorable.	Same as Alternative 2 except Remedy will achieve MCLs within approximately 37-years. Favorable.	Same as Alternative 2 except Remedy will achieve MCLs within approximately 37-years. Favorable.
Applicable or Relevant and Appropriate Requirements (ARARs)	Will not be in compliance with ARARs until MCLs are achieved (approximately 59-years). Not Favorable.	Will be in compliance with all ARARs with the exception of MCLs in groundwater. Will achieve MCLs in groundwater within approximately 59-years. Moderately Favorable	Same as Alternative 2; however, will achieve MCLs within approximately 37-years. Moderately Favorable	Same as Alternative 2; however, will achieve MCLs within approximately 37-years. Moderately Favorable
Long Term Effectiveness and Permanence	Not effective. Residual waste is uncontrolled and not managed or monitored through engineering and institutional controls or groundwater monitoring. Not Favorable.	Proven and reliable remedial technologies and associated controls. Effective. Existing engineering and institutional controls and groundwater monitoring combined with the SP-5 remediation system are already protective of human health and the environment. All ARARs are achieved with the exception of MCLs in groundwater. Favorable.	Same as Alternative 2. Favorable.	Same as Alternative 2. Favorable.

Table 5-2. Detailed Evaluation of Remedial Alternatives, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Alternatives	**ALTERNATIVE 1** No Action	**ALTERNATIVE 2** Monitored Natural Attenuation and Engineering and Institutional Controls until MCLs are Achieved (Approximately Fifty Nine (59) Years)	**ALTERNATIVE 3** Operation of the Existing ARI System until Groundwater MCLs are Achieved (Approximately Thirty Seven (37) Years) and Engineering and Institutional Controls	**ALTERNATIVE 4** No Further Action/Continued Operation of the Existing Remedies until MCLs are Achieved (Approximately Thirty Seven (37) Years)
Reduction of Toxicity, Mobility, or Volume of Contamination through Treatment	Residual contamination will ultimately be eliminated through intrinsic remediation (i.e., natural attenuation). Intrinsic remediation permanently and significantly reduces toxicity, mass, and volume through biodegradation and other abiotic processes which have been demonstrated at the site. Mobility is reduced through non-destructive processes such as sorption. Moderately Favorable	Same as Alternative 1. Moderately Favorable	Same as Alternative 1; however, timeframe to achieve equivalent reduction in mass is shorter. Favorable	Same as Alternative 3. Groundwater extraction provides insignificant added mass reduction. Favorable
Short Term Impacts and Effectiveness	Potential short-term impacts to human health and the environment due to discontinuation of engineering and institutional controls and inspections and monitoring. Unfavorable	No short term impacts. Favorable	No short term impacts. Favorable	No short term impacts. Favorable
Implementability	Technically and administratively implementable. Requires no activities. Favorable.	Technically and administratively implementable. Favorable.	Technically and administratively implementable. Favorable.	Technically and administratively implementable. Favorable.
Cost (1)	$0 Favorable.	Capital Costs: $312K O&M Costs (Years 1 through 2): $70K O&M Costs (Years 3 through 7): $52K O&M Costs (Years 8 through 59): $22K Total: $1.9M Favorable	Capital Costs: $312K O&M Costs (Years 1 through 37): $120K Total: $4.8M Unfavorable	Capital Costs: $312K O&M Costs (Years 1 through 37): $142K Total: $5.6M Unfavorable

Notes:

1. Refer to Appendix B for detailed cost calculations.

MCL Maximum contaminant level.
MNA Monitored natural attenuation.

ARCADIS

Table 6-1. Summary of Recommended Remedy, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Media/Area	Recommended Alternative (Alternative 2) and Rationale	Cost [1]
Groundwater	- Discontinue operation of the existing groundwater extraction system and existing ARI system and transition to MNA. - Continue to implement existing institutional controls (Section 2.3.8) for fifty nine (59)-years. - Continue to implement existing engineering controls (Section 2.3.9) for fifty nine (59)-years. - Implement additional engineering and institutional controls (Section 4) for fifty nine (59)-years. - Conduct natural attenuation monitoring for residual VOCs via groundwater/surface water/spring water monitoring. Implement revised long-term monitoring plan. - Continue operation of the existing SP-5 remediation system for twenty one (21)-years (Appendix A Table A-6) and continue to maintain the existing SP-4 infiltration bed and landfill cap for fifty nine (59)-years. Alternative 2 is recommended because it is capable of achieving groundwater MCLs in a timeframe comparable to Alternatives 3 and 4, is effective in the short-term and long-term, and is cost effective. Alternative 1 is not recommended because it is not protective of public health and the environment. Alternatives 3 and 4 are not recommended because, although each alternative achieves groundwater MCLs in a timeframe less than Alternative 2, the costs associated with these alternatives are significantly higher than the costs associated with Alternative 2 but provide little additional benefit to the overall remedial timeframe and no additional benefit to the protection of human health and the environment.	Capital Costs: $312K O&M Costs (Years 1 through 2): $70K O&M Costs (Years 3 O&M Costs (Years 8 through 59): $22K Total: $1.9M

Notes:

1. Detailed cost breakdowns are provided in Appendix B.

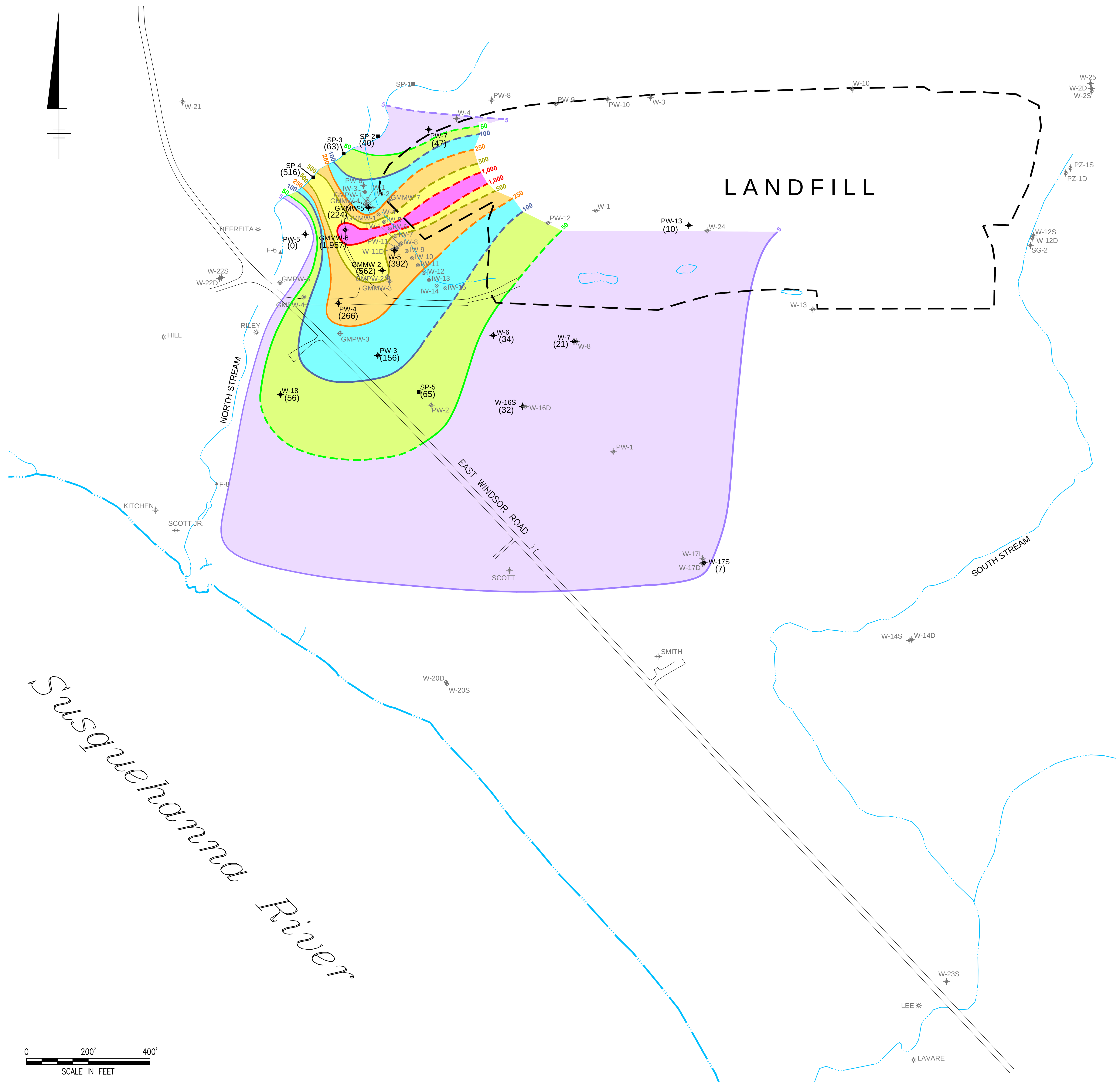
ARI	Automated reagent injection.
MNA	Monitored natural attenutation.
OMM	Operation, maintenance and monitoring.
VOC	Volatile organic compound.

COLESVILLE LANDFILL
COLESVILLE, NEW YORK
FOCUSED FEASIBILITY STUDY

LONG-TERM EFFECTIVENESS MONITORING LOCATIONS

ARCADIS

FIGURE
1-1



LEGEND:

- W-24 — LOCATION AND DESIGNATION OF MONITORING WELL
- SCOTT — LOCATION AND DESIGNATION OF EXISTING HOMEOWNER WELL
- HILL — LOCATION AND DESIGNATION OF FORMER HOMEOWNER WELL
- IW-2 — LOCATION AND DESIGNATION OF INJECTION WELL
- GMPW-3 — LOCATION AND DESIGNATION OF PRODUCTION WELL
- F-6 — LOCATION AND DESIGNATION OF SURFACE WATER SAMPLE
- SP-2 — LOCATION AND DESIGNATION OF SPRING SAMPLE
- TW-1 — LOCATION AND DESIGNATION OF TEST MONITORING WELL
- COCs — CONTAMINANTS OF CONCERN
- (65) — COC CONCENTRATION VALUE
- 1,000 — COC CONCENTRATION CONTOUR (DASHED WERE INFERRED)
- >5 ppb
- >50 ppb
- >100 ppb
- >250 ppb
- >500 ppb
- >1,000 ppb

NOTES:

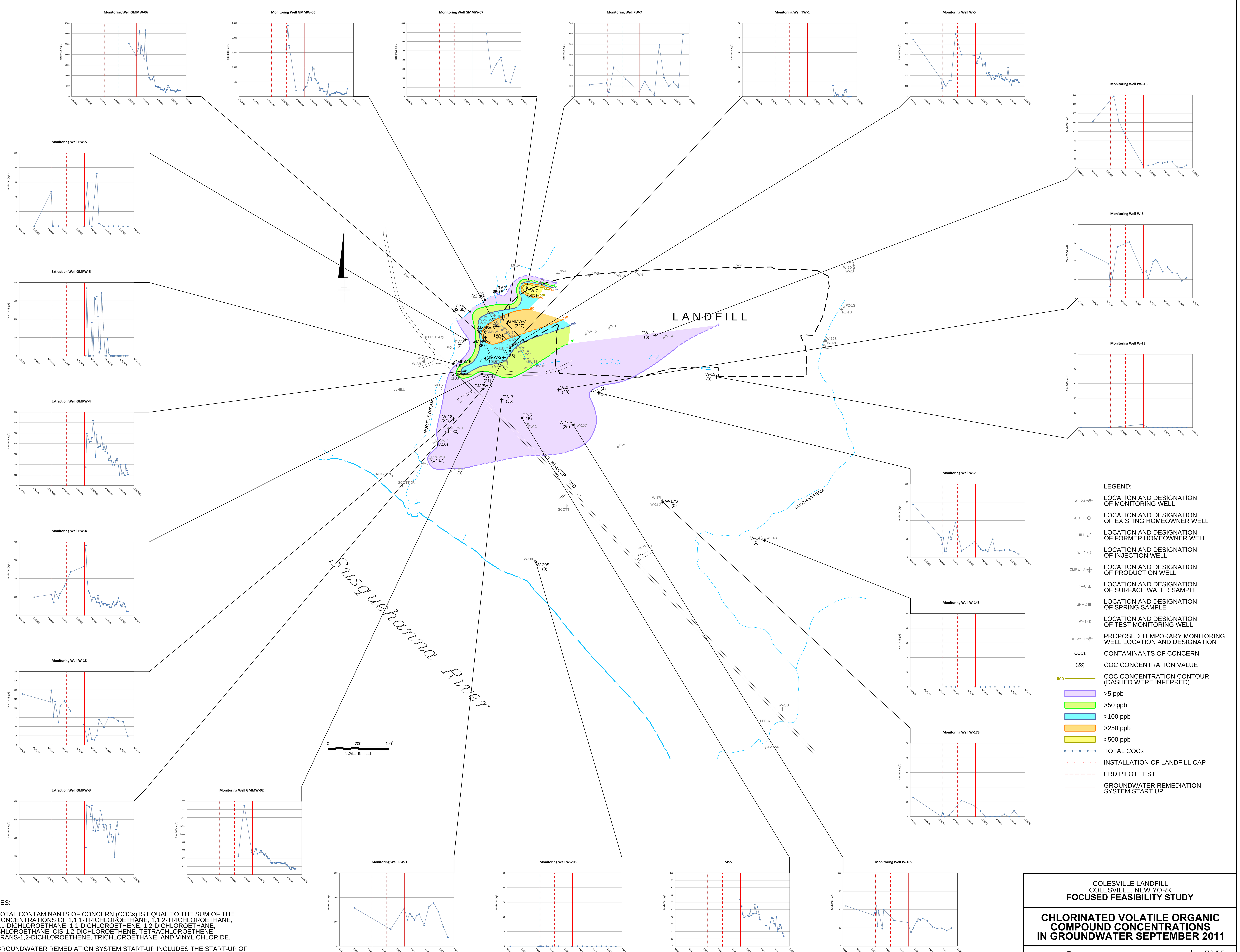
1. TOTAL CONTAMINANTS OF CONCERN (COCs) IS EQUAL TO THE SUM OF THE CONCENTRATIONS OF 1,1,1-TRICHLOROETHANE, 1,1,2-TRICHLOROETHANE, 1,1-DICHLOROETHANE, 1,1-DICHLOROETHENE, 1,2-DICHLOROETHANE, CHLOROETHANE, CIS-1,2-DICHLOROETHENE, TETRACHLOROETHENE, TRANS-1,2-DICHLOROETHENE, TRICHLOROETHENE, AND VINYL CHLORIDE.
2. ALL LOCATIONS ARE APPROXIMATE.

COLESVILLE LANDFILL
COLESVILLE, NEW YORK
FOCUSED FEASIBILITY STUDY

CHLORINATED VOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER JULY 2002

ARCADIS

FIGURE
2-1



NOTES:

1. TOTAL CONTAMINANTS OF CONCERN (COCs) IS EQUAL TO THE SUM OF THE CONCENTRATIONS OF 1,1,1-TRICHLOROETHANE, 1,1,2-TRICHLOROETHANE, 1,1-DICHLOROETHANE, 1,1-DICHLOROETHENE, 1,2-DICHLOROETHANE, CHLOROETHANE, CIS-1,2-DICHLOROETHENE, TETRACHLOROETHENE, TRANS-1,2-DICHLOROETHENE, TRICHLOROETHENE, AND VINYL CHLORIDE.
2. GROUNDWATER REMEDIATION SYSTEM START-UP INCLUDES THE START-UP OF THE GROUNDWATER EXTRACTION SYSTEM AND ENHANCED REDUCTIVE DECHLORINATION (ERD) SYSTEM.
3. ALL LOCATIONS ARE APPROXIMATE.

COLESVILLE LANDFILL
COLESVILLE, NEW YORK
FOCUSED FEASIBILITY STUDY

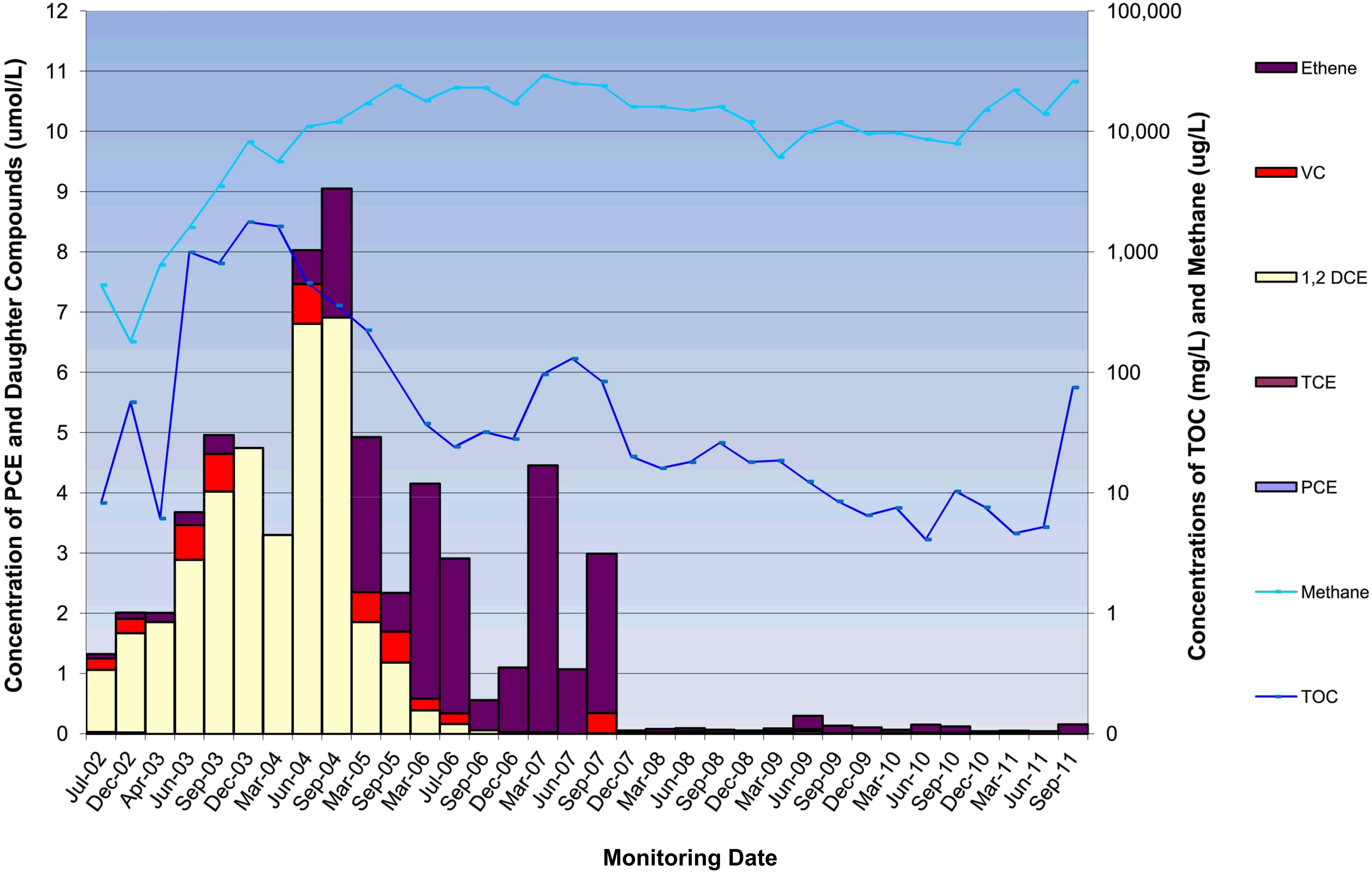
CHLORINATED VOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER SEPTEMBER 2011

ARCADIS

FIGURE
2-2

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
IMAGES: PROJECTNAME: ---
XREFS:

CITY:MELVILLE-NY DIV/GROUP:ENV DB:A.SANCHEZ LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
\\NY1FP1\Data\ENVCAD\Melville-NY\ACT\NY000949\0025\00005\NY949_25_5 F2-3_2-12.dwg LAYOUT: 2-3 SAVED: 4/23/2012 11:41 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 4/23/2012 11:42 AM BY: SANCHEZ, ADRIAN
XREFS: IMAGES: PROJECTNAME: ----

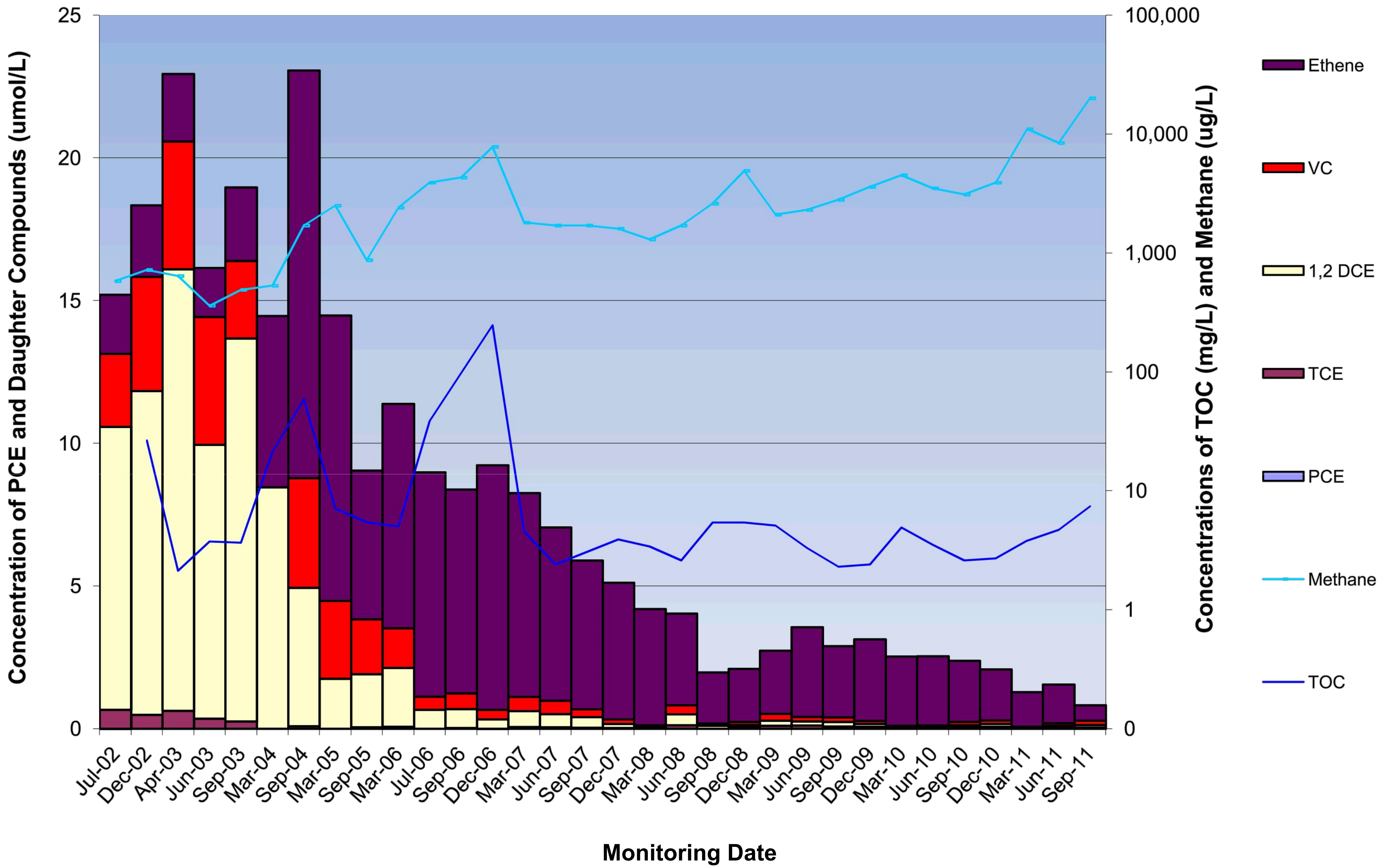


COLESVILLE LANDFILL
COLESVILLE, NEW YORK
FOCUSED FEASIBILITY STUDY

CONCENTRATIONS OF PCE DAUGHTER PRODUCTS VERSUS TIME IN GMMW-05

ARCADIS

FIGURE
2-3

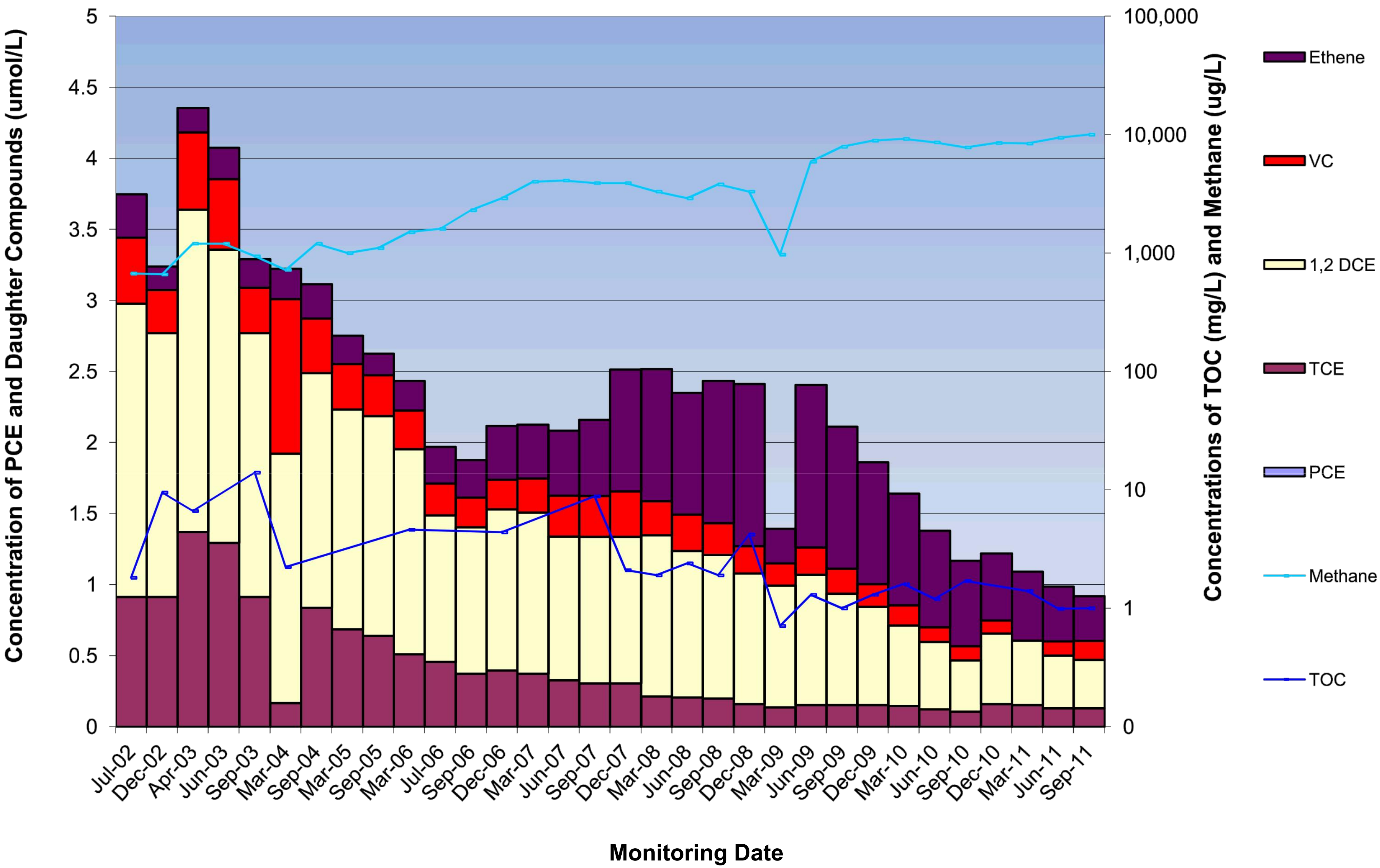


COLESVILLE LANDFILL
COLESVILLE, NEW YORK
FOCUSED FEASIBILITY STUDY

CONCENTRATIONS OF PCE DAUGHTER PRODUCTS VERSUS TIME IN GMMW-06

ARCADIS

FIGURE
2-4



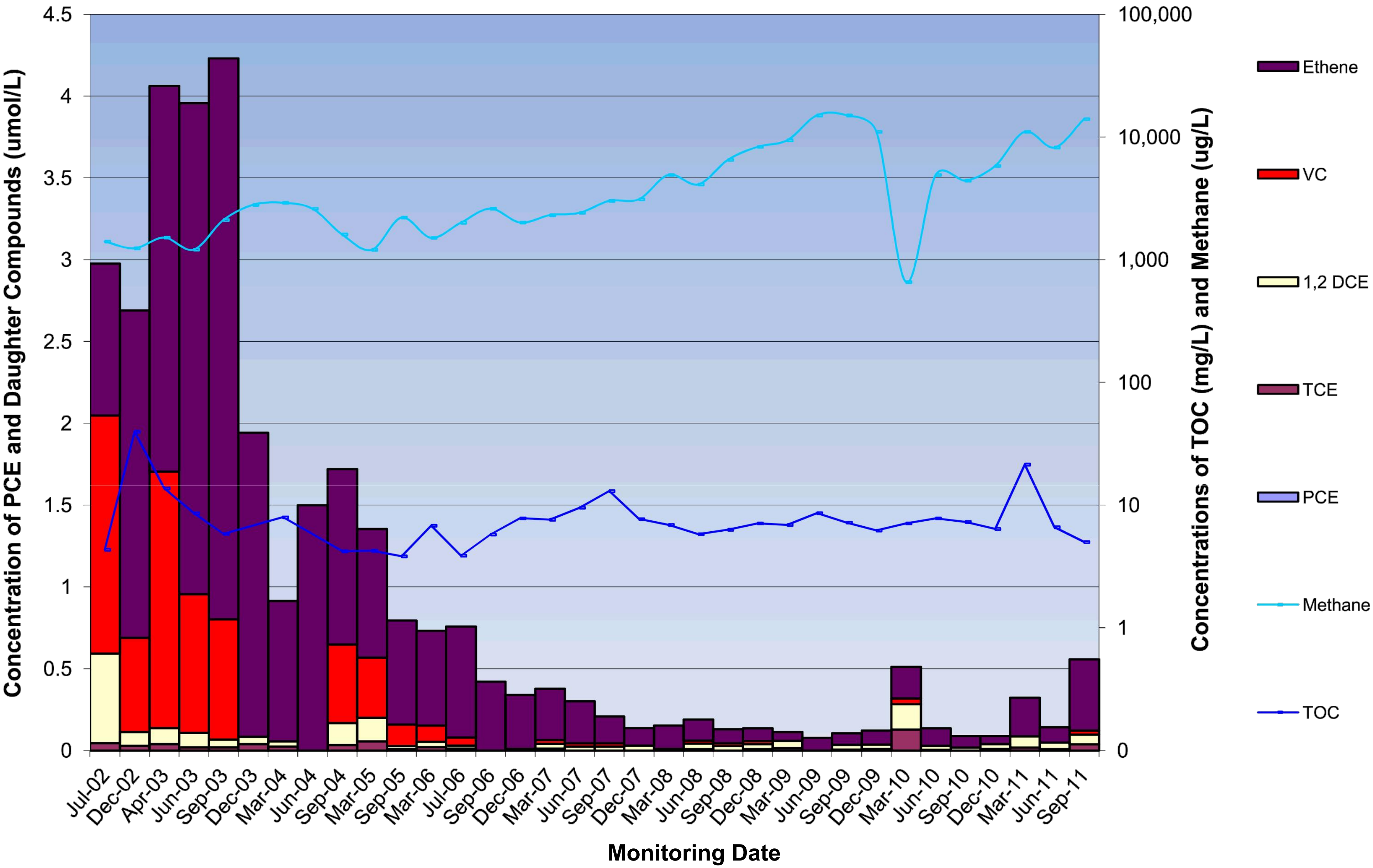
COLESVILLE LANDFILL
COLESVILLE, NEW YORK
FOCUSED FEASIBILITY STUDY

CONCENTRATIONS OF PCE DAUGHTER PRODUCTS VERSUS TIME IN GMMW-02

ARCADIS

FIGURE
2-5

CITY:MELVILLE-NY DIV/GROUP:ENV DB:A.SANCHEZ LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
\\NY1FP1\Data\ENVCAD\Melville-NY\ACT\NY000949\0025\00005\NY949_25_5 F2-3_2-12.dwg LAYOUT: 2-6 SAVED: 4/23/2012 11:41 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 4/23/2012 11:43 AM BY: SANCHEZ, ADRIAN
XREFS: IMAGES: PROJECTNAME: ----



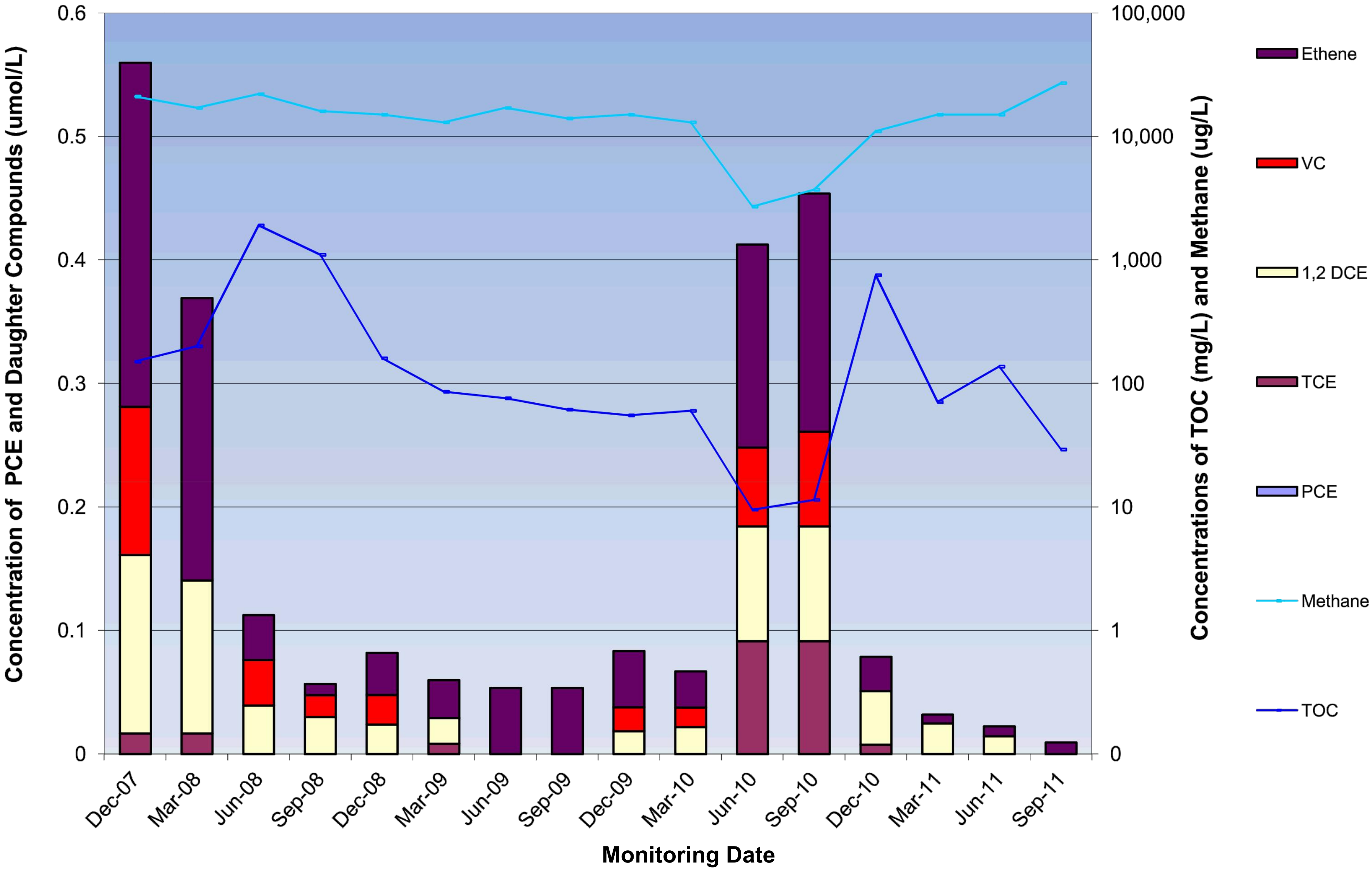
COLESVILLE LANDFILL
COLESVILLE, NEW YORK
FOCUSED FEASIBILITY STUDY

CONCENTRATIONS OF PCE DAUGHTER PRODUCTS VERSUS TIME IN W-05

ARCADIS

FIGURE
2-6

CITY:MELVILLE-NY DIV/GROUP:ENV DB:A.SANCHEZ LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
\\NY1FP1\Data\ENVCAD\Melville-NY\ACT\NY000949\0025\00005\NY949_25_5 F2-3_2-12.dwg LAYOUT: 2-7 SAVED: 4/23/2012 11:41 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 4/23/2012 11:43 AM BY: SANCHEZ, ADRIAN
XREFS: IMAGES: PROJECTNAME: ----



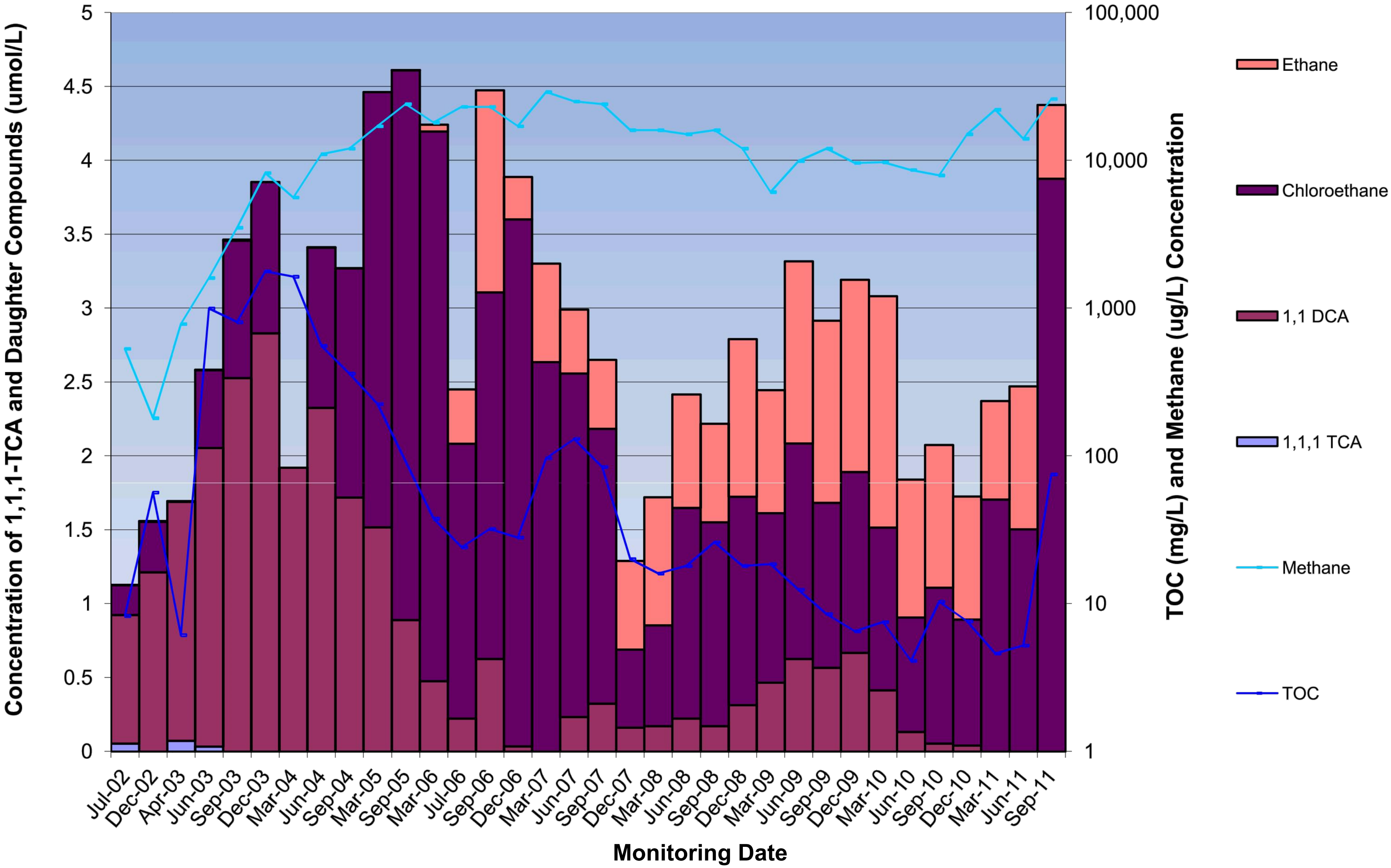
COLESVILLE LANDFILL
COLESVILLE, NEW YORK
FOCUSED FEASIBILITY STUDY

CONCENTRATIONS OF PCE DAUGHTER PRODUCTS VERSUS TIME IN TW-1

ARCADIS

FIGURE
2-7

CITY:MELVILLE-NY DIV/GROUP:ENV DB:A.SANCHEZ LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
\\NY1FP1\Data\ENVCAD\Melville-NY\ACT\NY000949\0025\00005\NY949_25_5 F2-3_2-12.dwg LAYOUT: 2-8 SAVED: 4/23/2012 11:41 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 4/23/2012 11:43 AM BY: SANCHEZ, ADRIAN
XREFS: IMAGES: PROJECTNAME: ----

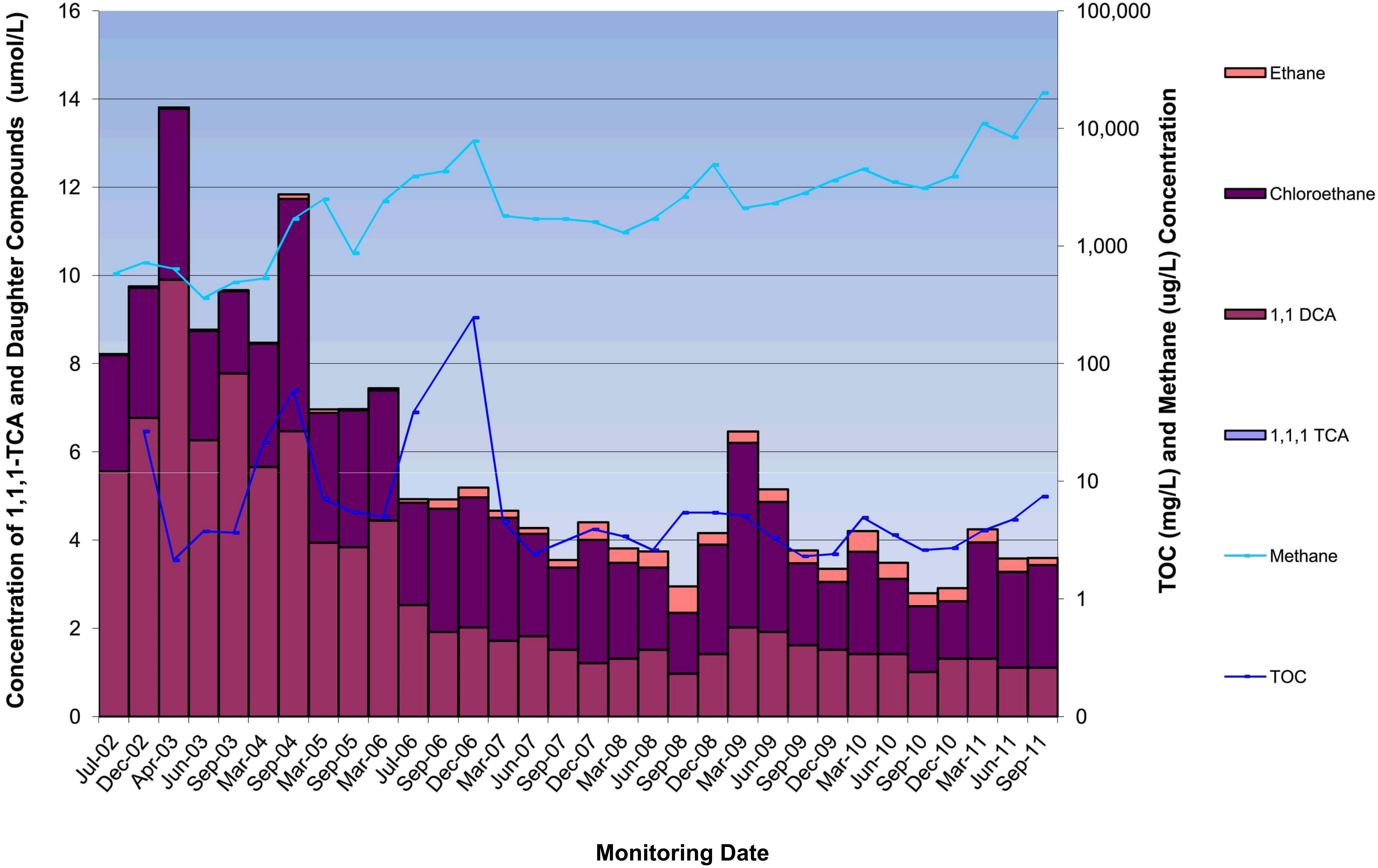


COLESVILLE LANDFILL
COLESVILLE, NEW YORK
FOCUSED FEASIBILITY STUDY

CONCENTRATIONS OF 1,1,1-TCA DAUGHTER PRODUCTS VERSUS TIME IN GMMW-05

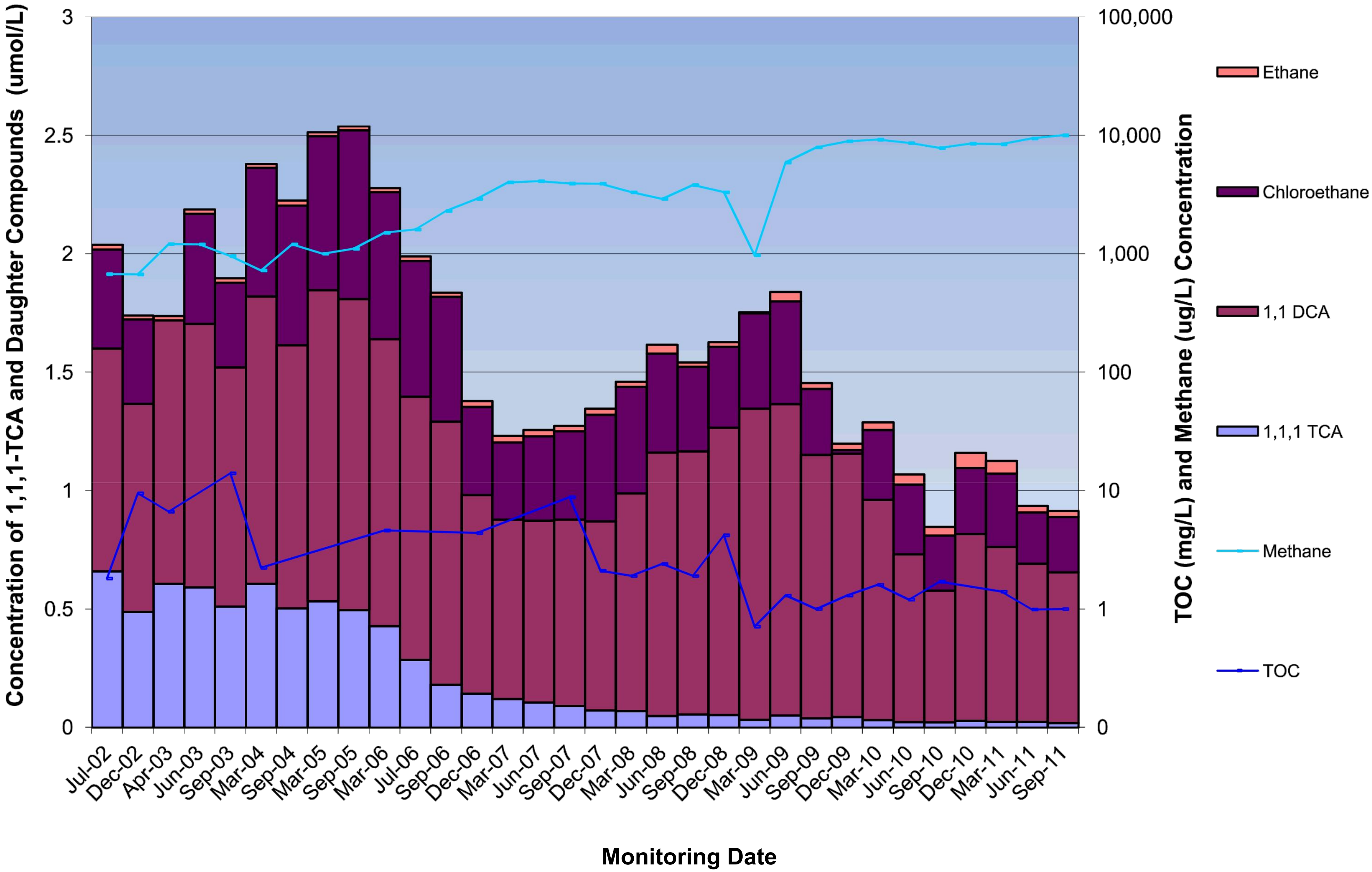
ARCADIS

FIGURE
2-8



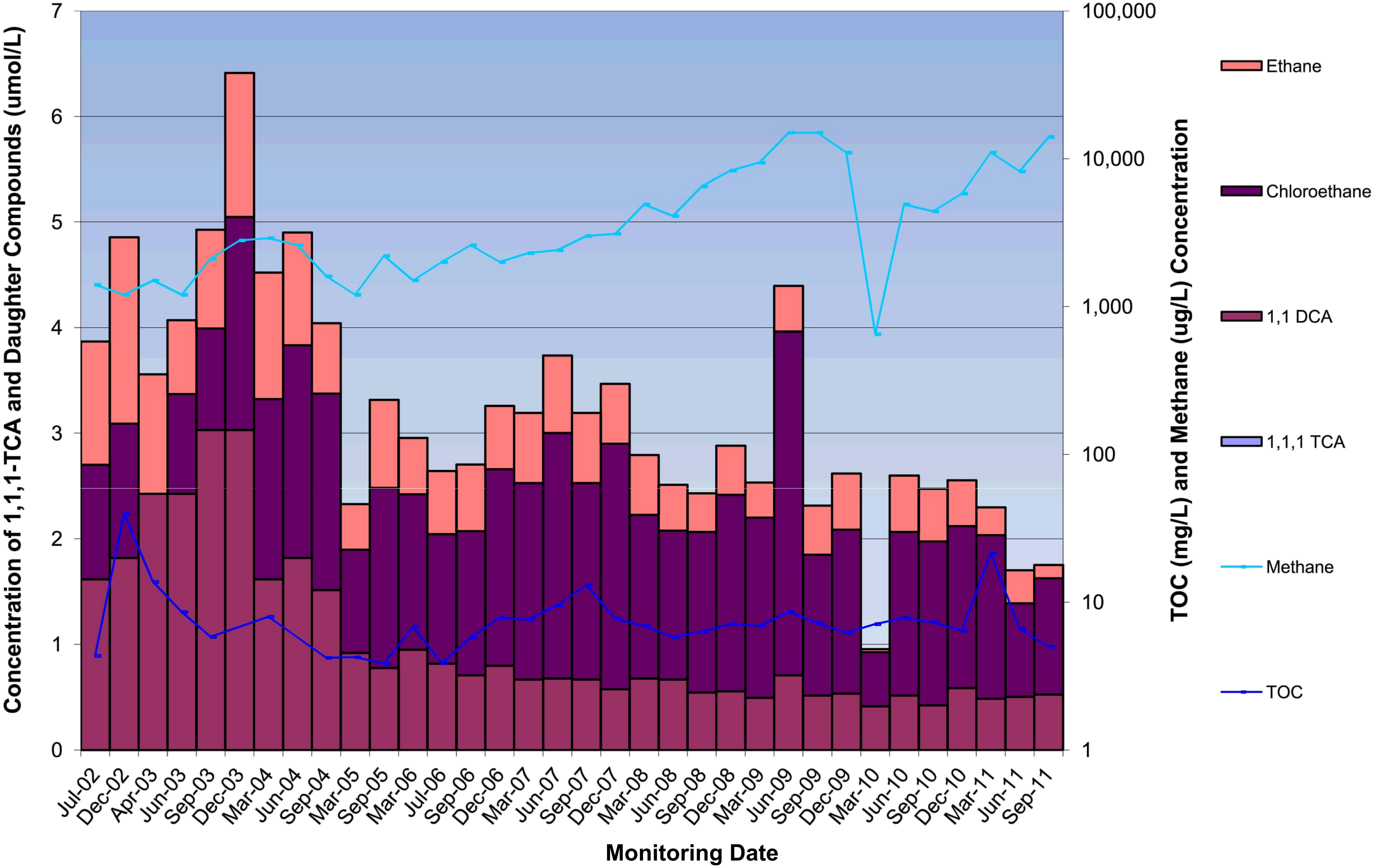
COLESVILLE LANDFILL COLESVILLE, NEW YORK **FOCUSED FEASIBILITY STUDY**	**CONCENTRATIONS OF 1,1,1-TCA DAUGHTER PRODUCTS VERSUS TIME IN GMMW-06**	ARCADIS	FIGURE **2-9**

CITY:MELVILLE-NY DIV/GROUP:ENV DB:A.SANCHEZ LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
\\NY1FP1\Data\ENVCAD\Melville-NY\ACT\NY000949\0025\00005\NY949_25_5 F2-3_2-12.dwg LAYOUT: 2-10 SAVED: 4/23/2012 11:43 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 4/23/2012 11:43 AM BY: SANCHEZ, ADRIAN
XREFS: IMAGES: PROJECTNAME: ----



COLESVILLE LANDFILL COLESVILLE, NEW YORK **FOCUSED FEASIBILITY STUDY**	**CONCENTRATIONS OF 1,1,1-TCA DAUGHTER PRODUCTS VERSUS TIME IN GMMW-02**	ARCADIS	FIGURE **2-10**

CITY:MELVILLE-NY DIV/GROUP:ENV DB:A.SANCHEZ LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
\\NY1FP1\Data\ENVCAD\Melville-NY\ACT\NY000949\0025\00005\NY949_25_5 F2-3_2-12.dwg LAYOUT: 2-11 SAVED: 4/23/2012 11:43 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 4/23/2012 11:43 AM BY: SANCHEZ, ADRIAN
XREFS: IMAGES: PROJECTNAME: ----



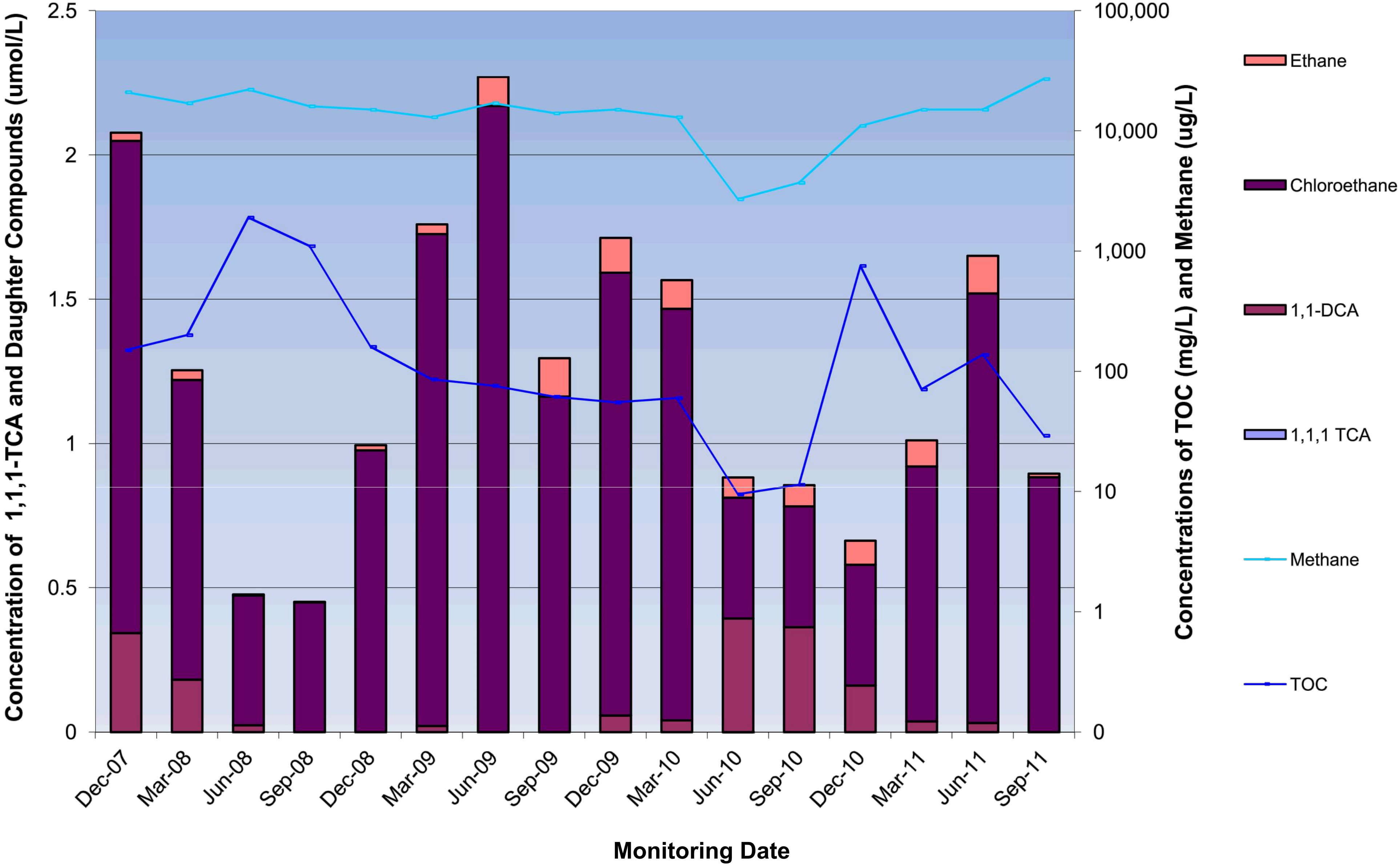
COLESVILLE LANDFILL
COLESVILLE, NEW YORK
FOCUSED FEASIBILITY STUDY

CONCENTRATIONS OF 1,1,1-TCA DAUGHTER PRODUCTS VERSUS TIME IN W-05

ARCADIS

FIGURE
2-11

CITY:MELVILLE-NY DIV/GROUP:ENV DB:A.SANCHEZ LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
\\NY1FP1\Data\ENVCAD\Melville-NY\ACT\NY000949\0025\00005\NY949_25_5 F2-3_2-12.dwg LAYOUT: 2-12 SAVED: 4/23/2012 11:43 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 4/23/2012 11:43 AM BY: SANCHEZ, ADRIAN
XREFS: IMAGES: PROJECTNAME: ----



COLESVILLE LANDFILL
COLESVILLE, NEW YORK
FOCUSED FEASIBILITY STUDY

CONCENTRATIONS OF 1,1,1-TCA DAUGHTER PRODUCTS VERSUS TIME IN TW-1

ARCADIS

FIGURE
2-12

ARCADIS

Appendix A

Data and Calculations

Table A-1. Current ARI System Mass Removal Calculations, Focused Feasibility Study, Colesville Landfill, Colesvile, New York.

Equations:

Total Mass Removed by ARI System = (Active Mass Flux through Treatment Zone) x (Operational Period) + (Total Adsorbed Mass Within Treatment Zone)

Active Mass Flux through Treatment Zone = (Average Advective GW Velocity) x (Average Injection Well Screen Thickness) x (Width of Treatment Zone) x (Average TVOC) x (Migratory Porosity)

Total Adsorbed Mass Within Treatment Zone = [(Injection Well Radius of Influence) + (Travel Distance Downgradient Based on Mass Transport Velocity)] x (Width of Treatment Zone) x (Average Well Screen Thickness) x (Average TVOC) x (Total Porosity)

Data and Calculations:

Average Advective GW Velocity (1)	0.4	ft/d
Average Injection Well Screen Thickness	20	ft.
Width of Treatment Zone (2)	500	ft.
Average TVOC (3)	265	ug/L
Migratory Porosity (1)	0.05	
Active Mass Flux through Treatment Zone	**1,523,380**	**ug/d**
Date of First Injection	9/1/2002	
Date of Last Injection	7/14/2011	
Operational Period	**3,238**	**d**
Injection Well Radius of Influence (4)	0.33	ft.
Mass Transport Velocity (5)	0.035	ft/d
Time Period Between Injections	262	d
TOC Travel Distance Downgradient (6)	9	ft.
Total Porosity (1)	0.4	
Total Adsorbed Mass within Treatment Zone	**299,699,621**	**ug**
Total Mass Removed by ARI System	**12.00**	**lbs**

See notes on last page.

Table A-1. Current ARI System Mass Removal Calculations, Focused Feasibility Study, Colesville Landfill, Colesvile, New York.

Notes

1. Refer to Section 2 of this FFS for additional information.
2. Width of treatment zone is equal to the width of the entire injection transect.
3. Average TVOC Concentration is equal to the average of the baseline monitoring wells GMMW-7 and W-5 chlorinated ethene concentrations.
4. Injection well radius of influence is equal to two times the injection well diameter.
5. Mass transport velocity calculated based upon bromide tracer results from the Hydraulic Injection Test and Alternate Electron Donor Pilot Test (ARCADIS 2006).
6. TOC travel distance downgradient calculated by multiplying the mass transfer velocity by the number of days between injections.

d	Days.
ft.	Feet.
f/d	Feet per day.
GW	Groundwater.
lbs.	Pounds.
ug/L	Micrograms per liter.

Table A-2. Downgradient Landfill Boundary Attenuation Data and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Location ID:		**GMMW-07**	**GMMW-07**	**GMMW-07**	**GMMW-07**	**GMMW-07**	**GMMW-07**	**GMMW-07**	
Date Collected:		**9/14/2005**	**9/21/2006**	**9/19/2007**	**9/18/2008**	**9/23/2009**	**9/22/2010**	**9/28/2011**	**Attenuation**
Cumulative Days:		**0**	**372**	**735**	**1,100**	**1,470**	**1,834**	**2,205**	**Rate (3)**
Sample Name:	**Units**	**GMMW-07**	**GMMW-07**	**GMMW-07**	**GMMW-7**	**GMMW-7**	**GMMW-7**	**GMMW-7**	**(d^{-1})**
Concentration (1)									
1,1,1-Trichloroethane	ug/L	16	0.0	6.5	5.6	3.1	0.0	0.0	NA
1,1,2-Trichloroethane	ug/L	2.2	0.0	1.0	0.0	0.0	0.0	0.0	NA
1,1-Dichloroethane	ug/L	240	74	110	140	55	47	110	NA
1,1-Dichloroethene	ug/L	2.6	0.0	1.4	1.4	0.0	0.0	0.9	NA
1,2-Dichloroethane	ug/L	2.4	0.0	0.0	1.3	0.0	0.0	0.0	NA
Chloroethane	ug/L	79	18	34	42	16	15	47	NA
cis-1,2-Dichloroethene	ug/L	200	110	130	130	40	62	89	NA
trans-1,2-Dichloroethene	ug/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NA
Tetrachloroethene	ug/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NA
Trichloroethene	ug/L	59	22	37	50	27	3.7	38	NA
Vinyl Chloride	ug/L	88	27	35	55	28	25	42	NA
Natural Log of Concentration (2)									
1,1,1-Trichloroethane	NA	2.77	--	1.87	1.72	1.13	--	--	-1.07E-03
1,1,2-Trichloroethane	NA	0.79	--	0.00	--	--	--	--	-1.07E-03
1,1-Dichloroethane	NA	5.48	4.30	4.70	4.94	4.01	3.85	4.70	-3.84E-04
1,1-Dichloroethene	NA	0.96	--	0.34	0.34	--	--	-0.07	-4.40E-04
1,2-Dichloroethane	NA	0.88	--	--	0.26	--	--	--	-5.57E-04
Chloroethane	NA	4.37	2.89	3.53	3.74	2.77	2.71	3.85	-2.61E-04
cis-1,2-Dichloroethene	NA	5.30	4.70	4.87	4.87	3.69	4.13	4.49	-4.63E-04
trans-1,2-Dichloroethene	NA	--	--	--	--	--	--	--	NA
Tetrachloroethene	NA	--	--	--	--	--	--	--	NA
Trichloroethene	NA	4.08	3.09	3.61	3.91	3.30	1.31	3.64	-5.06E-04
Vinyl Chloride	NA	4.48	3.30	3.56	4.01	3.33	3.22	3.74	-2.53E-04

See notes on last page.

Table A-2. Downgradient Landfill Boundary Attenuation Data and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Notes:

1. Data in this table corresponds to historic Monitoring Well GMMW-7 analytical data collected between 2002 and 2011. Chlorobenzene has been emitted from this evaluation due to inconsistent concentration trends throughout the life of the project.
2. Values calculated by taking the natural log of historic Monitoring Well GMMW-7 analytical data collected between 2002 and 2011.
3. Attenuation rate calculated by taking the slope of the first order time concentration data presented in this table:

$$\text{AttenuationRate} = \text{SLOPE}\left(\frac{\ln(\text{Concentration})}{\text{CumulativeDays}}\right)$$

NA Not applicable.

-- Value could not be calculated because the associated concentration value is zero (i.e., cannot calculate the natural log of zero).

Table A-3. Site-Wide Attenuation Rate Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Mass Travel Time Calculations:

Mass Transport Velocity (1) 0.035 ft/d

Well ID	Distance from Monitoring Well GMMW-7	Travel Time to Well (2)	
	(ft)	*(days)*	*(years)*
W-5	168	4,800	13
GMMW-2	228	6,514	18
PW-4	372	10,629	29
W-18	724	20,686	57

Analytical Data and Site-Wide Attenuation Rate Calculations:

Baseline - July 2002:

Location ID:		W-5	GMMW-2	PW-4	W-18
Date Collected:		7/24/2002	7/25/2002	7/25/2002	7/23/2002
Sample Name:	Units	W-5	GMMW-2	PW-4	W-18
Concentration (3)					
1,1,1-Trichloroethane	ug/L	8.5	88	69	12
1,1,2-Trichloroethane	ug/L	0.0	0.0	0.0	0.0
1,1-Dichloroethane	ug/L	160	93	62	15
1,1-Dichloroethene	ug/L	1.2	4.2	2.8	0.0
1,2-Dichloroethane	ug/L	1.3	0.0	0.0	0.0
Chloroethane	ug/L	70	27	17	0.0
cis-1,2-Dichloroethene	ug/L	53	200	72	9.8
trans-1,2-Dichloroethene	ug/L	0.0	0.0	0.0	0.0
Tetrachloroethene	ug/L	1.0	0.0	0.0	0.0
Trichloroethene	ug/L	6.0	120	38	19
Vinyl Chloride	ug/L	91	29	5.4	0.0

See notes on last page.

Table A-3. Site-Wide Attenuation Rate Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Natural Log of Concentration [4]						Attenuation Rate [5] (d^{-1})
1,1,1-Trichloroethane	NA	2.14	4.48	4.23	2.48	-1.47E-04 [6]
1,1,2-Trichloroethane	NA	--	--	--	--	--
1,1-Dichloroethane	NA	5.08	4.53	4.13	2.71	-1.41E-04
1,1-Dichloroethene	NA	0.18	1.44	1.03	--	-9.86E-05 [6]
1,2-Dichloroethane	NA	0.26	--	--	--	--
Chloroethane	NA	4.25	3.30	2.83	--	-2.19E-04
cis-1,2-Dichloroethene	NA	3.97	5.30	4.28	2.28	-2.10E-04 [6]
trans-1,2-Dichloroethene	NA	--	--	--	--	--
Tetrachloroethene	NA	0.00	--	--	--	--
Trichloroethene	NA	1.79	4.79	3.64	2.94	-1.19E-04 [6]
Vinyl Chloride	NA	4.51	3.37	1.69	--	-4.71E-04

Injection Baseline - December 2002

Location ID:		W-5	GMMW-2	PW-4	W-18
Date Collected:		12/10/2002	12/10/2002	12/10/2002	4/3/2003
Sample Name:	Units	W-5	GMMW-2	PW-4	W-18
Concentration [3]					
1,1,1-Trichloroethane	ug/L	6.6	65	62	0.0
1,1,2-Trichloroethane	ug/L	0.0	0.0	0.0	0.0
1,1-Dichloroethane	ug/L	180	87	73	0.0
1,1-Dichloroethene	ug/L	0.0	6.3	7.2	0.0
1,2-Dichloroethane	ug/L	0.0	0.0	0.0	0.0
Chloroethane	ug/L	82	23	20	0.0
cis-1,2-Dichloroethene	ug/L	8.2	180	130	0.0
trans-1,2-Dichloroethene	ug/L	0.0	0.0	0.0	0.0
Tetrachloroethene	ug/L	0.0	2.2	0.0	0.0
Trichloroethene	ug/L	3.8	120	82	11
Vinyl Chloride	ug/L	36	19	6.5	0.0

See notes on last page.

Table A-3. Site-Wide Attenuation Rate Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Natural Log of Concentration [4]						**Attenuation Rate** [5] **(d^{-1})**
1,1,1-Trichloroethane	NA	1.89	4.17	4.13	--	-1.15E-05 [6]
1,1,2-Trichloroethane	NA	--	--	--	--	--
1,1-Dichloroethane	NA	5.19	4.47	4.29	--	-1.34E-04
1,1-Dichloroethene	NA	--	1.84	1.97	--	--
1,2-Dichloroethane	NA	--	--	--	--	--
Chloroethane	NA	4.41	3.14	3.00	--	-2.04E-04
cis-1,2-Dichloroethene	NA	2.10	5.19	4.87	--	-7.91E-05 [6]
trans-1,2-Dichloroethene	NA	--	--	--	--	--
Tetrachloroethene	NA	--	0.79	--	--	--
Trichloroethene	NA	1.34	4.79	4.41	2.40	-1.74E-04 [6]
Vinyl Chloride	NA	3.58	2.94	1.87	--	-2.88E-04

Injection Intermediate - July 2006

Location ID:		**W-5**	**GMMW-2**	**PW-4**	**W-18**
Date Collected:		**7/27/2006**	**7/27/2006**	**7/27/2006**	**9/21/2006**
Sample Name:	**Units**	**W-5**	**GMMW-2**	**PW-4**	**W-18**
Concentration [3]					
1,1,1-Trichloroethane	ug/L	0.0	19	12	13
1,1,2-Trichloroethane	ug/L	0.0	0.0	0.0	0.0
1,1-Dichloroethane	ug/L	81	83	13	10
1,1-Dichloroethene	ug/L	0.0	1.3	0.0	0.0
1,2-Dichloroethane	ug/L	0.0	0.0	0.0	0.0
Chloroethane	ug/L	79	24	2.5	1.4
cis-1,2-Dichloroethene	ug/L	1.7	100	15	8.8
trans-1,2-Dichloroethene	ug/L	0.0	0.0	0.0	0.0
Tetrachloroethene	ug/L	0.0	0.0	0.0	0.0
Trichloroethene	ug/L	1.7	60	15	15
Vinyl Chloride	ug/L	3.1	14	0.0	0.0

See notes on last page.

Table A-3. Site-Wide Attenuation Rate Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Natural Log of Concentration [4]						**Attenuation Rate** [5] **(d^{-1})**	
1,1,1-Trichloroethane	NA	--	2.94	2.48	2.56	-2.03E-05	[6]
1,1,2-Trichloroethane	NA	--	--	--	--	--	
1,1-Dichloroethane	NA	4.39	4.42	2.56	2.30	-1.26E-04	[6]
1,1-Dichloroethene	NA	--	0.26	--	--	--	
1,2-Dichloroethane	NA	--	--	--	--	--	
Chloroethane	NA	4.37	3.18	0.92	0.34	-2.33E-04	
cis-1,2-Dichloroethene	NA	0.53	4.61	2.71	2.17	-1.49E-04	[6]
trans-1,2-Dichloroethene	NA	--	--	--	--	--	
Tetrachloroethene	NA	--	--	--	--	--	
Trichloroethene	NA	0.53	4.09	2.71	2.71	-3.37E-04	Excludes W-5 and W-18 data.
Vinyl Chloride	NA	1.13	2.64	--	--	--	

Injection Current - September 2012

Location ID:		**W-5**	**GMMW-2**	**PW-4**	**W-18**
Date Collected:		**9/28/2011**	**9/28/2011**	**9/28/2011**	**9/27/2011**
Sample Name:	**Units**	**W-5**	**GMMW-2**	**PW-4**	**W-18**
Concentration [3]					
1,1,1-Trichloroethane	ug/L	0.0	2.5	4.0	3.5
1,1,2-Trichloroethane	ug/L	0.0	0.0	0.0	0.0
1,1-Dichloroethane	ug/L	52	63	5.5	4.4
1,1-Dichloroethene	ug/L	0.0	0.0	0.0	0.0
1,2-Dichloroethane	ug/L	0.0	0.0	0.0	0.0
Chloroethane	ug/L	71	15	0.0	0.0
cis-1,2-Dichloroethene	ug/L	5.8	33	3.7	5.0
trans-1,2-Dichloroethene	ug/L	0.0	0.0	0.0	0.0
Tetrachloroethene	ug/L	0.0	0.0	0.0	0.0
Trichloroethene	ug/L	5.0	17	8.2	9.1
Vinyl Chloride	ug/L	1.4	8.4	0.0	0.0

See notes on last page.

Table A-3. Site-Wide Attenuation Rate Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Natural Log of Concentration (4)						Attenuation Rate (5) (d^{-1})	
1,1,1-Trichloroethane	NA	--	0.92	1.39	1.25	-1.33E-05	Excludes W-5 and GMMW-2 data.
1,1,2-Trichloroethane	NA	--	--	--	--	--	
1,1-Dichloroethane	NA	3.95	4.14	1.70	1.48	-1.57E-04	(6)
1,1-Dichloroethene	NA	--	--	--	--	--	
1,2-Dichloroethane	NA	--	--	--	--	--	
Chloroethane	NA	4.26	2.71	--	--	-9.07E-04	
cis-1,2-Dichloroethene	NA	1.76	3.50	1.31	1.61	-1.03E-04	(6)
trans-1,2-Dichloroethene	NA	--	--	--	--	--	
Tetrachloroethene	NA	--	--	--	--	--	
Trichloroethene	NA	1.61	2.83	2.10	2.21	-3.39E-05	(6)
Vinyl Chloride	NA	0.34	2.13	--	--	--	

Compound	Average Attenuation Rate (8) (d^{-1})	
1,1,1-Trichloroethane	-4.80E-05	(6)
1,1,2-Trichloroethane	--	
1,1-Dichloroethane	-1.40E-04	
1,1-Dichloroethene	-9.86E-05	
1,2-Dichloroethane	--	
Chloroethane	-3.91E-04	
cis-1,2-Dichloroethene	-1.35E-04	(6)
trans-1,2-Dichloroethene	--	
Tetrachloroethene	--	
Trichloroethene	-1.66E-04	(6)
Vinyl Chloride	-3.79E-04	

See notes on last page.

Table A-3. Site-Wide Attenuation Rate Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Notes:

1. Mass transport velocity calculated based upon bromide tracer results from the Hydraulic Injection Test and Alternate Electron Donor Pilot Test (ARCADIS 2006).
2. Travel time calculated by dividing the distance between the monitoring well and Monitoring Well GMMW-7 by the mass transport velocity.
3. Data in this table corresponds to historic Monitoring Well W-5, GMMW-2, PW-4, and W-18 analytical data collected between 2002 and 2011. Chlorobenzene has been emitted from this evaluation due to inconsistent concentration trends throughout the life of the project.
4. Values calculated by taking the natural log of historic monitoring well analytical data collected during the time period shown.
5. Attenuation rate calculated by taking the slope of the first order time concentration data presented in this table:

$$\text{Attenuation Rate} = \text{SLOPE}\left(\frac{\ln(\text{Concentration})}{\text{Travel Time to Monitoring Well GMMW - 7}}\right)$$

6. Monitoring Well W-5 data excluded from calculation due to apparent increase in concentration downgradient caused by biodegradation of the respective contaminant in the vicinity of Monitoring Well W-5.
7. Monitoring Well W-5 and GMMW-2 data excluded from calculation due to apparent increase in concentration downgradient caused by biodegradation of the respective contaminant in the vicinity of the monitoring wells.
8. Average attenuation rate calculated by taking the average of the baseline, injection baseline, injection intermediate, and injection current attenuation rates.

d^{-1} Per day.

d Days.

ft. Feet.

ft/d Feet per day.

ug/L Micrograms per liter.

-- Value could not be calculated due to insufficient data.

Table A-4. Summary of Attenuation Rates, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

	Natural Attenuation Rates (ARI System Offline)				Typical Half Life Values (4)
	Downgradient Landfill Boundary Half Life		**Site-Wide Half Life**		
	First Order Rate Constant (1) (d^{-1})	Compound Specific Half Life (2) (d) / (years)	First Order Rate Constant (3) (d^{-1})	Compound Specific Half Life (2) (d) / (years)	Anaerobic (years)
1,1,1-Trichloroethane	-1.07E-03	648 / 1.8	-4.80E-05	14,450 / 40	1.5 - 3.0
1,1,2-Trichloroethane	-1.07E-03	646 / 1.8	--	-- / --	2.0 - 4.0
1,1-Dichloroethane	-3.84E-04	1,804 / 4.9	-1.40E-04	4,965 / 14	0.35 - 1.7
1,1-Dichloroethene	-4.40E-04	1,575 / 4.3	-9.86E-05	7,033 / 19	0.22 - 0.5
1,2-Dichloroethane	-5.57E-04	1,244 / 3.4	--	-- / --	1.1 - 2.0
Chloroethane	-2.61E-04	2,655 / 7.3	-3.91E-04	1,774 / 4.9	0.08 - 0.3
cis-1,2-Dichloroethene	-4.63E-04	1,497 / 4.1	-1.35E-04	5,124 / 14	0.31 - 2.0
Tetrachloroethene	--	-- / --	--	-- / --	0.27 - 4.5
trans-1,2-Dichloroethene	--	-- / --	--	-- / --	0.31 - 2.0
Trichloroethene	-5.06E-04	1,370 / 3.8	-1.66E-04	4,176 / 11	0.27 - 4.5
Vinyl Chloride	-2.53E-04	2,736 / 7.5	-3.79E-04	1,828 / 5.0	0.31 - 2.0

Notes:

1. Values calculated using historical Monitoring Well GMMW-7 analytical data (see Table A-2). A first order rate constant was not calculated for chlorobenzene due to inconsistent concentration trends throughout the life of the project.
2. Compound specific half life calculated using a first order rate equation:

$$C = C_o e^{-kt}$$
$$at\ t = t_{1/2}, C/C_o = 0.5 \therefore$$
$$t_{1/2} = \frac{\ln\left(C/C_o\right)}{-k}$$

3. Values calculated using an average of analytical data collected over the life of the project from monitoring wells W-5, GMMW-2, PW-4, and W-18 (see Table A-3).
4. Values referenced in Handbook of Environmental Degradation Rates (Howard 1991).

d^{-1} Per day.
d Days.
-- Value could not be calculated due to insufficient data.

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Alternative 1 (No Action) and Alternative 2 (Monitored Natural Attenuation and Engineering and Institutional Controls) Calculations

Downgradient Landfill Boundary Attenuation Timeframes:

	MCL	Monitoring Well GMMW-7 Average Concentration (1)	Downgradient Landfill Boundary Compound-Specific Half Life (2)	Time to Reach MCLs (3)	
	(ug/L)	(ug/L)	(years)	(years)	
1,1,1-Trichloroethane	5	3.0	1.8	0	
1,1,2-Trichloroethane	5	0.20	1.8	0	
1,1-Dichloroethane	5	92	4.9	21	
1,1-Dichloroethene	5	0.75	4.3	0	
1,2-Dichloroethane	5	0.26	3.4	0	
Chloroethane	5	31	7.3	19	
cis-1,2-Dichloroethene	5	90	4.1	17	
Tetrachloroethene	5	0.0	--	--	
trans-1,2-Dichloroethene	5	0.0	--	--	
Trichloroethene	5	31	3.8	10	
Vinyl Chloride	2	37	7.5	31	Limiting Rate

Time for Clean Water Front to Reach Plume Boundary:

Mass Transport Velocity (4)	0.035	ft/d
Distance Between Monitoring Well GMMW-7 and End of Plume (5)	920	ft
Time (6)	26,286	days
	72	years

See notes on last page.

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Site Wide Attenuation Timeframes (IRZ Offline):

	MCL (ug/L)	Average Concentration (1) (ug/L)	Site-Wide Compound-Specific Half Life (2) (years)	Time to Reach MCLs (3) (years)	
1,1,1-Trichloroethane	5	6.4	40	13	
1,1,2-Trichloroethane	5	0.20	--	0	
1,1-Dichloroethane	5	92	14	57	
1,1-Dichloroethene	5	0.75	19	0	
1,2-Dichloroethane	5	0.26	--	0	
Chloroethane	5	31	5	13	
cis-1,2-Dichloroethene	5	90	14	59	Limiting Rate
Tetrachloroethene	5	0.0	--	0	
trans-1,2-Dichloroethene	5	0.0	--	0	
Trichloroethene	5	31	11	30	
Vinyl Chloride	2	37	5	21	

Alternatives 1 and 2 Total Remedial Timeframe:

Time for Site-Wide MNA to Reach MCLs	59	years	Site-wide MNA controls remedial timeframe. Alternative 1 requires no action during this time period, and Alternative 2 requires MNA for the entire time period.
Time for Monitoring Well GMMW-7 to Reach MCLs Plus Time for Clean Water Front to Reach Plume Boundary	103	years	

See notes on last page.

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Alternative 3 (Operation of the Existing ARI System until Remedial Action Objectives are Achieved) Calculations

Summary of Calculation Methodology:

An iterative process was used to determine the remedial timeframe for Alternatives 3 and 4. The estimated location of the clean water front was calculated assuming a number of years of operation. Historical analytical data from monitoring wells was then used to estimate the current average concentration of each compound at the estimated location of the clean water front. The average compound concentration was then used in a first order rate equation (see Alternative 1 calculations) to determine the number of years for each compound to degrade (through attenuation processes) to MCLs. This process was repeated until the time period for compound concentrations to reach MCLs was equal to the timeframe required for the clean water front to reach the location of the average compound concentrations.

The results of the iterative process indicate that after 37-years of operation, the clean water front will be approximately 592-feet from the injection transect. An average of analytical results from samples collected from Monitoring Wells PW-4 and W-18 and Recovery Well GMPW-4 over the past 5-years of system operati
was used to represent current compound concentrations 592-feet from the injection transect.

Estimated Location of Clean Water Front after Thirty Seven (37) Years of ARI System Operation:

Mass Transport Velocity [(4)]	0.035	ft/d
Date of First Injection	9/1/2002	
Years of Operation	37	years
Estimated Location of Clean Water Front [(10)]	592	ft from injection transect

See notes on last page.

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Site Wide Attenuation Timeframes (IRZ Operating):

	Site-Wide Compound-Specific Half Life (2)	MCL	Average Concentration	Time to Achieve MCLs (3)	
	(years)	(ug/L)	(ug/L)	(years)	
1,1,1-Trichloroethane	40	5	9.6	$\boxed{37}$	Limiting Rate
1,1,2-Trichloroethane	--	5	0.0	--	
1,1-Dichloroethane	14	5	34	$\boxed{37}$	Limiting Rate
1,1-Dichloroethene	19	5	0.40	0.0	
1,2-Dichloroethane	--	5	0.0	--	
Chloroethane	4.9	5	14	7.1	
cis-1,2-Dichloroethene	14	5	26	33	
Tetrachloroethene	--	5	0.0	--	
trans-1,2-Dichloroethene	--	5	0.0	--	
Trichloroethene	11	5	33	31	
Vinyl Chloride	5.0	2	4.7	6.2	

Location of Clean Water Front

Mass Transport Velocity (4)	0.035	ft/d
Date of First Injection	9/1/2002	
Location of Clean Water Front (10)	120	ft from injection transect

Time for Clean Water Front to Reach End of Plume:

Mass Transport Velocity (4)	0.035	ft/d
Distance Between Clean Water Front and End of Plume (5)	748	ft
Time (6)	21,381	days
	59	years

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

See notes on last page.

Alternative 3 Total Remedial Timeframe:

Time for Contaminants to Reach MCLs	37	years	Controlled by the site-wide MNA rate for when the IRZ is operating.
Time for Monitoring Well GMMW-7 to Reach MCLs Plus Time for Clean Water Front to Reach Plume Boundary	59	years	

Alternative 4 (No Further Action/Continue Existing Remedy) Calculations

Same remedial timeframe as Alternative 3. Refer to Alternative 3 calculations.

Total Remedial Timeframe:

Time:	37	years	Controlled by the site-wide MNA rate for when the IRZ is operating; Pumping provides no additional remedial benefit.

Summary of Remedial Timeframes

Alternative	Remedial Timeframe
Alternative 1	59 years
Alternative 2	59 years
Alternative 3	37 years
Alternative 4	37 years

See notes on last page.

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Notes:

1. Average concentration calculated by taking an average of historic Monitoring Well GMMW-7 analytical data collected over the past five years of system operation.
2. Refer to Tables A-2 through A-4 for compound-specific half life calculations.
3. Time to reach MCLs calculated using the compound-specific half life:

Calculate "n" Using the Following Equation :

$$C = C_o\left(\frac{1}{2^n}\right)$$

C = Final Compound Concentration (MCL)

C_o = Initial Compound Concentration (Avg. Conc.)

n = Number of Half Lives Elapsed

Time to Reach MCLs $= t_{1/2} \times n$

n = Number of Half Lives Elapsed

$t_{1/2}$ = Compound Specific Half Life

4. Mass transport velocity calculated based upon bromide tracer results from the Hydraulic Injection Test and Alternate Electron Donor Pilot Test (ARCADIS 2006).
5. The distance to the end of the plume was determined using data from the Volatile Organic Compound Plume Delineation Report (ARCADIS 2011).
6. Time for clean water front to reach the end of the plume was calculated by dividing the distance to the end of the plume by the mass transport velocity.
7. Travel time to East Windsor Road was calculated by dividing the distance between Monitoring Well GMMW-7 and East Windsor Road by the mass transport velocity.

Notes continued on next page.

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Notes Continued:

8. Target Monitoring Well GMMW-7 concentration is the concentration of each contaminant at Monitoring Well GMMW-7 that will naturally degrade to below MCLs by the time mass reaches East Windsor Road. The target GMMW-7 concentration is the point where operation of the existing ARI system would be discontinued. Values were calculated using a first order rate equation:

Calculate C_o Using First Order Rate Equation:

$$C = C_o e^{-kt}$$

C = Final Contaminant Concentration (MCL)

C_o = Initial Contaminant Concentration

k = Attenuation Rate

t = Travel Time to East Windsor Road

9. Time to reach target Monitoring Well GMMW-7 concentrations calculated using the compound-specific half life:

Calculate "n" Using the Following Equation:

$$C = C_o \left(\frac{1}{2^n}\right)$$

C = Final Compound Concentration (Target GMMW-7 Concentration)

C_o = Initial Compound Concentration (Avg. Conc.)

n = Number of Half Lives Elapsed

Time to Reach MCLs $= t_{1/2} \times n$

n = Number of Half Lives Elapsed

$t_{1/2}$ = Compound Specific Half Life

10. Current location of clean water front calculated by multiplying the mass transport velocity by the time period between the present and the date of the first injection minus one year. One year is subtracted from the time period to account for the time for the injection zone to establish itself.

11. Average concentration calculated by taking an average of analytical data from samples collected from Recovery Wells GMPW-3 and GMPW-4 and Monitoring Wells GMMW-2 and PW-4 collected over the past five years of system operation. These concentrations represent current concentrations at the location of the clean water front.

ft Feet.
ft/d Feet per day.
IRZ In-situ reactive zone.
MCL Maximum contaminant level.
MNA Monitored natural attenuation.
ug/L Micrograms per liter.

ARCADIS

Table A-6. Summary of SP-5 Remedial Timeframe Estimate and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Current Location of Clean Water Front:		
Mass Transport Velocity (1)	0.035	ft/d
Date of First Injection	9/1/2002	
Current Location of Clean Water Front (2)	120	ft from injection transect
Time for Clean Water Front to Reach SP-5:		
Mass Transport Velocity (1)	0.035	ft/d
Distance Between Injection Transect and SP-5	384	ft
Distance Between Clean Water Front and SP-5	264	ft
Time (3)	7,552	days
	21	years

Notes:

1. Mass transport velocity calculated based upon bromide tracer results from the Hydraulic Injection Test and Alternate Electron Donor Pilot Test (ARCADIS 2006).
2. Current location of clean water front calculated by multiplying the mass transport velocity by the time period between the present and the date of the first injection minus one year. One year is subtracted from the time period to account for the time for the injection zone to establish itself.
3. Time for clean water front to reach SP-5 calculated by dividing the distance between the clean water front and SP-5 by the mass transport velocity. Value represents an estimate for cost estimating purposes only.

ft Feet.
ft/d Feet per day.

Table A-7. Remedial Alternative Mass Removal Estimates, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Plume Mass Estimate:

Average Plume Thickness [1]	20	ft
Total Porosity [2]	0.4	

TVOC	July 2002 (Baseline Conditions)	
	Area [3]	Mass [4]
(ug/L)	*(ft^2)*	*(lbs.)*
5	1,167,779	2.9
50	242,615	6.1
100	146,612	7.3
250	77,531	9.7
500	35,342	8.8
1,000	9,224	
	TOTAL	**34.8**

TVOC	September 2011 (Current Conditions)	
	Area [3]	Mass [4]
(ug/L)	*(ft^2)*	*(lbs.)*
5	632,471	1.6
50	97,242	2.4
100	57,614	2.9
250	26,627	3.3
500	2,214	0.6
	TOTAL	**10.8**

See notes on last page.

Table A-7. Remedial Alternative Mass Removal Estimates, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Groundwater Extraction System Mass Removal Estimate:

Alternative 1: NA

Alternative 2: NA

Alternative 3: NA

Alternative 4:

Estimated Mass Removal Rate (5):	0.03	lbs/year
Estimated Operational Period (6):	37	years
Estimated Mass to be Removed (7):	**0.93**	**lbs**

ARI System Mass Removal Estimate:

Alternative 1: NA

Alternative 2: NA

Alternative 3:

Average Advective Groundwater Velocity (2)	0.4	ft/d
Average Injection Well Screen Thickness	20	ft.
Width of Treatment Zone (8)	500	ft.
Average TVOC (9)	19	ug/L
Migratory Porosity (2)	0.05	
Active Mass Flux through Treatment Zone	**109,922**	**ug/d**
Operational Period	**13,505**	**d**
Total Mass Removed by ARI System	**4.0**	**lbs**

Alternative 4:

Same as Alternative 3	**4.0**	**lbs**

See notes on last page.

Table A-7. Remedial Alternative Mass Removal Estimates, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

SP-5 Spring Water Remediation System Mass Removal Estimate:

Alternative 1 through Alternative 4:

Estimated Mass Removal Rate (5):	0.17	lbs/year
Estimated Operational Period (6):	21	years
Estimated Mass to be Removed (7,10):	**3.5**	**lbs**

Notes:

1. Average plume thickness is equal to the average injection well screen thickness.
2. Refer to Section 2 of this FFS for additional information.
3. Area estimates extracted from Figures 2-1 and 2-2. The unknown source mass controlled by the landfill cap was not included in calculations. Accordingly, these calculations represent treatment of the dissolved phase plume located downgradient of the landfill cap
4. Plume mass estimated using the following equation:

$$Mass = Area \times Average\,Plume\,Thickness \times Total\,Porosity \times TVOC \times 28.32\,\frac{L}{ft^3} \times 2.2 \times 10^{-9}\,\frac{lb}{ug}$$

5. Estimated mass removal rate calculated by dividing the Operational Year 9 mass removal rate (as stated in the operation, maintenance and monitoring reports) by two. The Operational Year 9 mass removal rate was divided by two to account for the declining influent concentration trend.
6. Refer to Table A-5 (Appendix A) for remedial timeframe estimates.
7. Estimated mass to be removed calculated by multiplying the estimated mass removal rate by the operational time period.
8. Width of treatment zone is equal to the width of the entire injection transect.
9. Average TVOC Concentration estimated by using the downgradient landfill boundary half lives (Table A-4, Appendix A) to determine what the TVOC concentration will be at the mid point of the remedial timeframe (i.e, after 18.5 years).
10. Refer to Table A-8 (Appendix A) for a summary of Remedial Alternative mass removal estimates.

ARI	Automated reagent injection.
FFS	Focused feasibility study.
ft.	Feet.
ft^2	Square feet.
L/ft^3	Liters per cubic foot.
lb/ug	Pounds per microgram
lbs.	Pounds.
MNA	Monitored natural attenuation.
NA	Not applicable.
TVOC	Total volatile organic compounds.
ug/L	Micrograms per liter.

ARCADIS

Table A-8. Summary of Remedial Alternative Mass Removal Estimates, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Summary of Mass Removal Estimates:

Remedial Alternative (1)	Remedial Timeframe (1)	Total Mass (2)	Total Mass Removed through Active Remediation (3)	Total Mass Removed through MNA (4)	Overall Active Remediation Mass Removal Rate (5)	Overall MNA Mass Removal Rate (6)	Overall Active Remediation Cost Rate (7)	Overall Remediation Cost Rate (8)	Active Remediation Incremental Cost Rate (9)
	(years)	(lbs)	(lbs)	(lbs)	(lbs/year)	(lbs/year)	($/lb)	($/lb)	($/lb)
1	59	10.8	0.0	10.8	0	1.82E-01	--		--
2	59	10.8	3.5	7.3	5.87E-02	1.24E-01	$536,508	$172,732	--
3	37	10.8	7.5	3.3	2.02E-01	8.91E-02	$637,562	$442,228	$101,054
4	37	10.8	8.4	2.4	2.27E-01	6.41E-02	$663,409	$517,175	$126,901

Notes:

1. Refer to Section 5.2 of this FFS for a description of Remedial Alternatives 1 through 4.
2. Refer to Plume Mass Estimate calculations on Table A-7 (Appendix A).
3. Active remediation refers to operation of the Groundwater Extraction System, ARI System, and SP-5 Remediation Systems. Refer to Mass Estimate calculations on Table A-7 (Appendix A).
4. Total mass removed through MNA calculated by subtracting the total mass removed through active remediation from the total mass.
5. Overall active remediation mass removal rate calculated by dividing the total mass removed through active remediation by the remedial timeframe.
6. Overall MNA mass removal rate calculated by dividing the total mass removed through MNA by the remedial timeframe.
7. Overall active remediation cost rate calculated by dividing the total remedial alternative cost (Appendix B) by the total mass removed through active remediation.
8. Overall remediation cost rate calculated by dividing the total remedial alternative cost (Appendix B) by the total mass.
9. Active remediation incremental cost rate calculated by subtracting the overall active remediation cost rate for Alternatives 3 and 4 from the overall active remediation cost rate for Alternative 2. This calculation provides a comparison of the active remediation alternatives to Alternative 2 (MNA).

ARI Automated reagent injection system.
FFS Focused feasibility study.
lbs. Pounds.
MNA Monitored natural attenuation.
-- Not applicable.
$/lb Dollars per pound.

ARCADIS

Appendix B

Remedial Alternatives Detailed Cost Estimates

Table B1. Detailed Costs of Remedial Alternative 2, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Monitored Natural Attenuation and Engineering and Institutional Controls

Includes:

- *Discontinue operation of the existing groundwater extraction system.*
- *Discontinue operation of the existing automated reagent injection system.*
- *Implement monitored natural attenuation until MCLs are achieved (59-Years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing engineering controls (Section 2.3.9) until MCLs are achieved (59-years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing institutional controls (Section 2.3.10) until MCLs are achieved (59-years; Refer to Table A-5, Appendix A).*
- *Implement additional engineering and institutional controls (Sections 4 and 5.2.2) until MCLs are achieved (59-years; Refer to Table A-5, Appendix A).*
- *Implement revised long-term monitoring program until MCLs are achieved (59-years; Refer to Comments below).*

Description	Quantity	Units	Unit Cost ($)	Total Cost ($)	Comments
Site Closure and Demobilization					
Project Management	1	ls	$15,000	$15,000	All fees associated with management of construction related aspects of the project.
Well Abandonment	73	ea	$750	$54,750	Well abandonment in accordance with NYSDEC CP-43 Groundwater Monitoring Well Decomissioning Policy.
Building Removal	1	ea	$50,000	$50,000	All fees for construction activities associated with removal of the treatment building.
Site Closure Labor	1	ea	$25,000	$25,000	Includes oversight labor for construction activities associated with decommissioning the remedial infrastructure.
Project Management/Regulatory Communications/Meetings	1	ls	$15,000	$15,000	All fees associated with internal communications and meetings associated with site closure and demobilization.
Two Years Post-Closure Groundwater Monitoring and Reporting	1	ls	$100,000	$100,000	Includes labor and laboratory analytical costs associated with two years of post-closure groundwater monitoring and reporting.
Subtotal Site Closure and Demobilization				**$260,000**	
SUBTOTAL CAPITAL COST				**$260,000**	
CAPITAL COST CONTINGENCY				**$52,000**	20% contingency.
TOTAL CAPITAL COST WITH CONTINGENCY ALTERNATIVE 2				**$312,000**	Rounded to the nearest 100.

Table B1. Detailed Costs of Remedial Alternative 2, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Monitored Natural Attenuation and Engineering and Institutional Controls

Includes:

- *Discontinue operation of the existing groundwater extraction system.*
- *Discontinue operation of the existing automated reagent injection system.*
- *Implement monitored natural attenuation until MCLs are achieved (59-Years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing engineering controls (Section 2.3.9) until MCLs are achieved (59-years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing institutional controls (Section 2.3.10) until MCLs are achieved (59-years; Refer to Table A-5, Appendix A).*
- *Implement additional engineering and institutional controls (Sections 4 and 5.2.2) until MCLs are achieved (59-years; Refer to Table A-5, Appendix A).*
- *Implement revised long-term monitoring program until MCLs are achieved (59-years; Refer to Comments below).*

Description	Quantity	Units	Unit Cost ($)	Total Cost ($)	Comments
Annual Operation and Maintenance and Long-Term Activities					
<u>*Years 1 through 2 (Semi-Annual Monitoring and Reporting)*</u>					
Project Management	1	ls	$18,000	$18,000	Project management.
Engineering Controls/Institutional Controls Inspections and Certifications	1	ls	$7,500	$7,500	Annual site verification inspections and reporting by NYS PE.
Media Replacement	1	ls	$1,350	$1,350	Assumes GAC replacement at SP-5 once per year (years 1 through 21; Appendix A Table A-6).
Waste Management Costs	1	ls	$250	$250	Disposal of SP-5 spent GAC one per year (years 1 through 21; Appendix A Table A-6).
Performance Monitoring Labor	1	ls	$12,140	$12,140	Assumes semi-annual monitoring of water-levels, select groundwater monitoring wells, and surface water/spring water, and annual monitoring of select groundwater monitoring wells for costing purposes. Includes costs for equipment rental and supplies.
Laboratory Analytical	2	ls	$2,575	$5,150	Laboratory analytical for groundwater samples and SP-5 samples. Assumes semi-annual monitoring of 5 groundwater monitoring wells and 5 surface water/spring water locations, and annual monitoring of 12 groundwater monitoring wells for costing purposes.
Field Management and Data Evaluation	2	ls	$5,300	$10,600	Engineers estimate for management of field staff and data evaluation.
Reporting	1	ls	$8,500	$8,500	Engineers estimate for semi-annual reporting plus one annual report.
Contingency	10%	of	$63,490	$6,349	Contingency for OM&M.
Subtotal Annual OM&M and Long-Term Activities (Years 1 through 2)				**$69,900**	Rounded to the nearest 100.

Table B1. Detailed Costs of Remedial Alternative 2, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Monitored Natural Attenuation and Engineering and Institutional Controls

Includes:

- *Discontinue operation of the existing groundwater extraction system.*
- *Discontinue operation of the existing automated reagent injection system.*
- *Implement monitored natural attenuation until MCLs are achieved (59-Years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing engineering controls (Section 2.3.9) until MCLs are achieved (59-years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing institutional controls (Section 2.3.10) until MCLs are achieved (59-years; Refer to Table A-5, Appendix A).*
- *Implement additional engineering and institutional controls (Sections 4 and 5.2.2) until MCLs are achieved (59-years; Refer to Table A-5, Appendix A).*
- *Implement revised long-term monitoring program until MCLs are achieved (59-years; Refer to Comments below).*

Description	Quantity	Units	Unit Cost ($)	Total Cost ($)	Comments
Years 3 through 7 (Annual Monitoring and Reporting)					
Project Management	1	ls	$12,000	$12,000	Project management.
Engineering Controls/Institutional Controls Inspections and Certifications	1	ls	$7,500	$7,500	Annual site verification inspections and reporting by NYS PE.
Media Replacement	1	ls	$1,350	$1,350	Assumes GAC replacement at SP-5 once per year (years 1 through 21; Appendix A Table A-6).
Waste Management Costs	1	ls	$250	$250	Disposal of SP-5 spent GAC one per year (years 1 through 21; Appendix A Table A-6).
Performance Monitoring Labor	1	ls	$7,620	$7,620	Assumes annual monitoring of water-levels and groundwater/surface water/spring for costing purposes. Includes costs for equipment rental and supplies.
Laboratory Analytical	1	ls	$4,265	$4,265	Laboratory analytical for groundwater samples and SP-5 samples. Assumes annual monitoring of 23 groundwater/surface water/spring water locations for costing purposes.
Field Management and Data Evaluation	1	ls	$7,900	$7,900	Engineers estimate for management of field staff and data evaluation.
Reporting	1	ls	$6,000	$6,000	Engineers estimate for annual reporting.
Contingency	10%	of	$46,885	$4,689	Contingency for OM&M.
Subtotal Annual OM&M and Long-Term Activities (Years 3 through 7)				**$51,600**	Rounded to the nearest 100.

Table B1. Detailed Costs of Remedial Alternative 2, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Monitored Natural Attenuation and Engineering and Institutional Controls

Includes:

- *Discontinue operation of the existing groundwater extraction system.*
- *Discontinue operation of the existing automated reagent injection system.*
- *Implement monitored natural attenuation until MCLs are achieved (59-Years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing engineering controls (Section 2.3.9) until MCLs are achieved (59-years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing institutional controls (Section 2.3.10) until MCLs are achieved (59-years; Refer to Table A-5, Appendix A).*
- *Implement additional engineering and institutional controls (Sections 4 and 5.2.2) until MCLs are achieved (59-years; Refer to Table A-5, Appendix A).*
- *Implement revised long-term monitoring program until MCLs are achieved (59-years; Refer to Comments below).*

Description	Quantity	Units	Unit Cost ($)	Total Cost ($)	Comments
Years 8 through 59 (Bi-Annual Monitoring and Reporting)					
Project Management	1	ls	$3,000	$3,000	Project management.
Engineering Controls/Institutional Controls Inspections and Certifications	1	ls	$3,750	$3,750	Annual site verification inspections and reporting by NYS PE.
Media Replacement	1	ls	$338	$338	Assumes GAC replacement at SP-5 once per year (years 1 through 21; Appendix A Table A-6).
Waste Management Costs	1	ls	$63	$63	Disposal of SP-5 spent GAC one per year (years 1 through 21; Appendix A Table A-6).
Performance Monitoring Labor	1	ls	$3,810	$3,810	Assumes biennial water-levels and groundwater/surface water/spring water monitoring for costing purposes. Includes costs for equipment rental and supplies.
Laboratory Analytical	1	ls	$2,133	$2,133	Laboratory analytical for groundwater samples and SP-5 samples. Assumes biennial monitoring of 23 groundwater/surface water/spring water locations for costing purposes.
Field Management and Data Evaluation	1	ls	$3,950	$3,950	Engineers estimate for management of field staff and data evaluation.
Reporting	1	ls	$3,000	$3,000	Engineers estimate for bi-annual reporting.
Contingency	10%	of	$20,043	$2,004	Contingency for OM&M.
Subtotal Annual OM&M and Long-Term Activities (Years 8 through 59)				**$22,100**	Rounded to the nearest 100.
PRESENT WORTH OM&M AND LONG-TERM ACTIVITIES COST ALTERNATIVE 2			**$**	**1,547,000**	Rounded to the nearest 100.
TOTAL COST ALTERNATIVE 2			**$**	**1,859,000**	Rounded to the nearest 100.

Abbreviations:

ea	Each.
GAC	Granular activated carbon.
ls	Lump sum.
MCL	Maximum contaminant level.
NYS PE	New York State professional engineer.
OM&M	Operation, maintenance, and monitoring.

ARCADIS

Table B2. Detailed Costs of Remedial Alternative 3, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Operation of the Existing Automated Reagent Injection System and Engineering and Institutional Controls:

Includes:

- *Discontinue operation of the existing groundwater extraction system.*
- *Operate the existing automated reagent injection system until MCLs are achieved (37-Years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing engineering controls (Section 2.3.9) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing institutional controls (Section 2.3.10) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Implement additional engineering and institutional controls (Sections 4 and 5.2.4) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Implement revised long-term monitoring program until MCLs are achieved (37-years; Refer to Comments below).*

Description	Quantity	Units	Unit Cost ($)	Total Cost ($)	Comments
Site Closure and Demobilization					
Project Management	1	ls	$15,000	$15,000	All fees associated with management of construction related aspects of the project.
Well Abandonment	73	ea	$750	$54,750	Well abandonment in accordance with NYSDEC CP-43 Groundwater Monitoring Well Decomissioning Policy.
Building Removal	1	ea	$50,000	$50,000	All fees for construction activities associated with removal of the treatment building.
Site Closure Labor	1	ea	$25,000	$25,000	Includes oversight labor for construction activities associated with decommissioning the remedial infrastructure.
Project Management/Regulatory Communications/Meetings	1	ls	$15,000	$15,000	All fees associated with internal communications and meetings associated with site closure and demobilization.
Two Years Post-Closure Groundwater Monitoring and Reporting	1	ls	$100,000	$100,000	Includes labor and laboratory analytical costs associated with two years of post-closure groundwater monitoring and reporting.
Subtotal Site Closure and Demobilization				**$260,000**	
SUBTOTAL CAPITAL COST				**$260,000**	
CAPITAL COST CONTINGENCY				**$52,000**	20% contingency.
TOTAL CAPITAL COST WITH CONTINGENCY ALTERNATIVE 3				**$312,000**	

Table B2. Detailed Costs of Remedial Alternative 3, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Operation of the Existing Automated Reagent Injection System and Engineering and Institutional Controls:

Includes:

- *Discontinue operation of the existing groundwater extraction system.*
- *Operate the existing automated reagent injection system until MCLs are achieved (37-Years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing engineering controls (Section 2.3.9) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing institutional controls (Section 2.3.10) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Implement additional engineering and institutional controls (Sections 4 and 5.2.4) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Implement revised long-term monitoring program until MCLs are achieved (37-years; Refer to Comments below).*

Description	Quantity	Units	Unit Cost ($)	Total Cost ($)	Comments
Annual Operation and Maintenance and Long-Term Activities					
Years 1 through 37 (Semi-Annual Monitoring and Reporting)					
Project Management	1	ls	$24,000	$24,000	Project management.
Engineering Controls/Institutional Controls Inspections and Certifications	1	ls	$7,500	$7,500	Annual site verification inspections and reporting by NYS PE.
Media Replacement	1	ls	$673	$673	Assumes GAC replacement at SP-5 once per year (years 1 through 21; Appendix A Table A-6).
Waste Management Costs	1	ls	$135	$135	Disposal of SP-5 spent GAC one per year (years 1 through 21; Appendix A Table A-6).
Mol-Whey Injections	1	ls	$21,000	$21,000	Includes Baker tank rental, water deliveries, and Mol-Whey costs. Assumes injection every six months.
Mol-Whey Injection Labor	1	ls	$6,720	$6,720	Assumes injection every six months.
Mol-Why Injection Spare Parts	1	ls	$1,800	$1,800	Replacement of flow meters, pumps, etc.
Performance Monitoring Labor	2	ls	$4,520	$9,040	Assumes semi-annual monitoring of water-levels, select groundwater monitoring wells, and surface water/spring water, and annual monitoring of select groundwater monitoring wells for costing purposes. Completion of mol-whey injections every six months.
Equipment Replacement	1	ls	$1,500	$1,500	Replacement of flow meters, pumps, etc.
Utilities	1	ls	$5,800	$5,800	Includes electric, phone and internet utilities.
Laboratory Analytical	1	ls	$2,437	$2,437	Laboratory analytical for groundwater samples and SP-5 samples. Assumes semi-annual monitoring of 5 groundwater monitoring wells and 5 surface water/spring water location, and annual monitoring of 12 groundwater monitoring wells for costing purposes.
Field Management and Data Evaluation	2	ls	$5,300	$10,600	Engineers estimate for management of field staff and data evaluation.
Reporting	1	ls	$18,000	$18,000	Engineers estimate for semi-annual reporting plus one annual report.

Table B2. Detailed Costs of Remedial Alternative 3, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Operation of the Existing Automated Reagent Injection System and Engineering and Institutional Controls:

Includes:

- *Discontinue operation of the existing groundwater extraction system.*
- *Operate the existing automated reagent injection system until MCLs are achieved (37-Years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing engineering controls (Section 2.3.9) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing institutional controls (Section 2.3.10) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Implement additional engineering and institutional controls (Sections 4 and 5.2.4) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Implement revised long-term monitoring program until MCLs are achieved (37-years; Refer to Comments below).*

Description	Quantity	Units	Unit Cost ($)	Total Cost ($)	Comments
Contingency	10%	of	$109,204	$10,920	Contingency for OM&M.
Subtotal Annual OM&M and Long-Term Activities (Years 1 through 37)				**$120,200**	Rounded to the nearest 100.
PRESENT WORTH OM&M AND LONG-TERM ACTIVITIES COST ALTERNATIVE 3				**$ 4,447,400**	Rounded to the nearest 100.
TOTAL COST ALTERNATIVE 3				**$ 4,759,400**	Rounded to nearest 100.

Abbreviations:

ea	Each.
GAC	Granular activated carbon.
ls	Lump sum.
MCL	Maximum contaminant level.
NYS PE	New York State professional engineer.
OM&M	Operation, maintenance, and monitoring.

Table B3. Detailed Costs of Remedial Alternative 4, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Continue Operation of Existing Remedy:

Includes:

- *Operate the existing groundwater extraction system and existing automated reagent injection system until MCLs are achieved (37-Years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing engineering controls (Section 2.3.9) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing institutional controls (Section 2.3.10) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Implement additional engineering and institutional controls (Sections 4 and 5.2.4) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Implement revised long-term monitoring program until MCLs are achieved (37-years; Refer to Comments below).*

Description	Quantity	Units	Unit Cost ($)	Total Cost ($)	Comments
Site Closure and Demobilization					
Project Management	1	ls	$15,000	$15,000	All fees associated with management of construction related aspects of the project.
Well Abandonment	73	ea	$750	$54,750	Well abandonment in accordance with NYSDEC CP-43 Groundwater Monitoring Well Decomissioning Policy.
Building Removal	1	ea	$50,000	$50,000	All fees for construction activities associated with removal of the treatment building.
Site Closure Labor	1	ea	$25,000	$25,000	Includes oversight labor for construction activities associated with decommissioning the remedial infrastructure.
Project Management/Regulatory Communications/Meetings	1	ls	$15,000	$15,000	All fees associated with internal communications and meetings associated with site closure and demobilization.
Two Years Post-Closure Groundwater Monitoring and Reporting	1	ls	$100,000	$100,000	Includes labor and laboratory analytical costs associated with two years of post-closure groundwater monitoring and reporting.
Subtotal Site Closure and Demobilization				**$260,000**	
SUBTOTAL CAPITAL COST				**$260,000**	
CAPITAL COST CONTINGENCY				**$52,000**	20% contingency.
TOTAL CAPITAL COST WITH CONTINGENCY ALTERNATIVE 4				**$312,000**	Rounded to the nearest 100.

Table B3. Detailed Costs of Remedial Alternative 4, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Continue Operation of Existing Remedy:

Includes:

- *Operate the existing groundwater extraction system and existing automated reagent injection system until MCLs are achieved (37-Years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing engineering controls (Section 2.3.9) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing institutional controls (Section 2.3.10) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Implement additional engineering and institutional controls (Sections 4 and 5.2.4) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Implement revised long-term monitoring program until MCLs are achieved (37-years; Refer to Comments below).*

Description	Quantity	Units	Unit Cost ($)	Total Cost ($)	Comments
Annual Operation and Maintenance and Long-Term Activities					
Years 1 through 37 (Semi-Annual Monitoring and Reporting)					
Project Management	1	ls	$24,000	$24,000	Project management.
Engineering Controls/Institutional Controls Inspections and Certifications	1	ls	$7,500	$7,500	Annual site verification inspections and reporting by NYS PE.
Media Replacement	1	ls	$673	$673	Assumes GAC replacement at SP-5 once per year (years 1 through 21; Appendix A Table A-6).
Waste Management Costs	1	ls	$135	$135	Disposal of SP-5 spent GAC one per year (years 1 through 21; Appendix A Table A-6).
Mol-Whey Injections	1	ls	$21,000	$21,000	Includes Baker tank rental, water deliveries, and Mol-Whey costs. Assumes injection every six months.
Mol-Whey Injection Labor	1	ls	$6,720	$6,720	Assumes injection every six months.
Mol-Whey Injection Spare Parts	1	ls	$1,800	$1,800	Replacement of flow meters, pumps, etc.
Performance Monitoring Labor	2	ls	$4,520	$9,040	Assumes semi-annual monitoring of water-levels, select groundwater monitoring wells, and surface water/spring water, and annual monitoring of select groundwater monitoring wells for costing purposes.
Equipment Replacement	1	ls	$1,500	$1,500	Replacement of flow meters, pumps, etc.
Utilities	1	ls	$5,800	$5,800	Includes electric, phone and internet utilities.
Laboratory Analytical	1	ls	$3,187	$3,187	Laboratory analytical for groundwater samples, groundwater extraction system samples, and SP-5 samples. Assumes semi-annual monitoring of 5 groundwater monitoring wells, the groundwater extraction system and 5 surface water/spring water location, and annual monitoring of 12 groundwater monitoring wells for costing purposes.
Field Management and Data Evaluation	2	ls	$5,300	$10,600	Engineers estimate for management of field staff and data evaluation.
Reporting	1	ls	$22,000	$22,000	Engineers estimate for semi-annual reporting plus one annual report.
Groundwater Extraction System Maintenance Labor and Spare Parts	1	ls	$15,100	$15,100	Engineers estimate for groundwater extraction system maintenance and spare parts.

Table B3. Detailed Costs of Remedial Alternative 4, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Continue Operation of Existing Remedy:

Includes:

- *Operate the existing groundwater extraction system and existing automated reagent injection system until MCLs are achieved (37-Years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing engineering controls (Section 2.3.9) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Continue to implement existing institutional controls (Section 2.3.10) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Implement additional engineering and institutional controls (Sections 4 and 5.2.4) until MCLs are achieved (37-years; Refer to Table A-5, Appendix A).*
- *Implement revised long-term monitoring program until MCLs are achieved (37-years; Refer to Comments below).*

Description	Quantity	Units	Unit Cost ($)	Total Cost ($)	Comments
Contingency	10%	of	$129,054	$12,905	Contingency for OM&M.
Subtotal Annual OM&M and Long-Term Activities (Years 1 through 37)				**$142,000**	Rounded to the nearest 100.
PRESENT WORTH OM&M AND LONG-TERM ACTIVITIES COST ALTERNATIVE 4				**$ 5,254,000**	Rounded to the nearest 100.
TOTAL COST ALTERNATIVE 4				**$ 5,566,000**	Rounded to the nearest 100.

Abbreviations:

ea	Each.
GAC	Granular activated carbon.
ls	Lump sum.
MCL	Maximum contaminant level.
NYS PE	New York State professional engineer.
OM&M	Operation, maintenance, and monitoring.