NEW YORK STATE SUPERFUND CONTRACT

New Cassel Industrial Area
Offsite Groundwater
Town of North Hempstead, Nassau County

Remedial Investigation/ Feasibility Study (RI/FS) Report

Volume II • Feasibility Study Report

Work Assignment No. D002676-42.1

September 2000

Prepared for:

New York State Department of Environmental Conservation

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ENGINEERING AND OPERATIONS SERVICES
NEW YORK STATE SUPERFUND STANDBY CONTRACT

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CHAPTER 7

APPLICABLE STANDARDS, CRITERIA, AND GUIDANCE

7.1 INTRODUCTION

This chapter identifies applicable standards, criteria, and guidance that are used in the development of the health exposure pathway analysis (Chapter 8) and the feasibility study (Chapters 9 through 12) for the NCIA off-site groundwater. Applicable requirements are defined as those promulgated Federal or state requirements (e.g., drinking water standards or standards of control) that specifically address a hazardous substance, pollutant, or contaminant found at a Federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site. Relevant and appropriate requirements are those Federal, state, or local requirements that, while not directly applicable, address items that are sufficiently similar to those encountered at CERCLA sites. Collectively, these terms are commonly referred to as applicable or relevant and appropriate requirements, or ARARs. In addition to ARARs, other criteria, advisories, or guidance may apply to the conditions found at a site; these are referred to as to-be-considered (TBC) items. TBCs are not legally binding but may be useful in evaluating site risks and determining site cleanup goals.

In the New York State regulations (6 NYCRR Part 375), the equivalent term for "ARARs" is "standards and criteria" and the equivalent term for "TBCs" is "guidance". Within New York State regulations, these terms are grouped together and referred to as "standards, criteria, and guidance" or SCGs.

SCGs are generally divided into three item-specific categories: chemical, location, and action. Chemical-specific SCGs provide guidance on acceptable or permissible contaminant concentrations in environmental media such as soil, air, and water. Location-specific SCGs govern activities in critical environments such as floodplains, potable source aquifers, wetlands, endangered species habitats, or historically significant areas. Action-specific SCGs are technology- or activity-based requirements. The SCGs described in this chapter are of possible importance to the health exposure pathway analysis and to the FS.

Some SCGs establish numerical values to limit the discharge or ambient concentration for a particular contaminant. In order to determine if a condition or activity complies with applicable SCGs, a list of specific contaminants of concern (COCs) is organized based on site-specific environmental data. For the NCIA off-site groundwater, the list of COCs includes those contaminants that are present in significant concentrations in groundwater, as identified in the RI and determined in the health exposure pathway analysis (Chapter 8). The list includes PCE, TCE, 1,1,1-TCA, 1,1-DCE, 1,2-DCE, 1,1-DCA, 1,2-DCA, and vinyl chloride. The SCGs for these COCs are summarized in Table 7-1 and discussed below.

7.2 CHEMICAL SPECIFIC SCGs

7.2.1 New York State Groundwater Standards

For this FS, the NCIA "site" is defined as the properties bounded by the Long Island Railroad to the north, Old Country Road to the south, Grand Boulevard and Grand Street to the west, and Frost Street to the east. Groundwater contamination from the NCIA extends south and southwest in the direction of groundwater flow. This FS addresses the off-site groundwater, or the portions of the VOC contaminant plumes that are south of Old Country Road and Grand Boulevard. Aquifers underlying the FS focus area (i.e., off-site groundwater) are each designated as a "Class GA" groundwater, which is defined by the New York State Groundwater Standards to be as follows: "The best usage of Class GA waters is as a source of potable water supply. Class GA waters are fresh groundwaters found in the saturated zone of unconsolidated deposits and consolidated rock or bedrock." Therefore, the Class GA groundwater standards are intended for protection of human health where groundwater is used as a drinking water supply. Numerical groundwater standards and guidance values are presented in 6 New York Code of Rules and Regulations (NYCRR) Part 703 and NYSDEC's Division of Water (DOW) Technical and Operational Guidance Series (TOGS) 1.1.1 titled "Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations" (NYSDEC 1998). The Class GA groundwater standards are equivalent to criteria established by the New York State Department of Health (NYSDOH) for public water supplies. The NYSDOH criteria were promulgated in NYCRR Title 10 Chapter I (State Sanitary Code) Subpart 5-1. The New York State standards are equivalent to, or are more stringent than, Federal maximum contaminant levels (MCLs) established by the United States Environmental Protection Agency (USEPA). For the off-site groundwater,

TABLE 7-1

STANDARDS, CRITERIA, AND GUIDANCE VALUES

New Cassel Industrial Area Off-site Groundwater

	PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1,1-TCA	1,1-DCE	1,1-DCA	1,2-DCA	VC
NYS Groundwater Standards - Class GA (µg/l) (a)	5 **	5 **	5 **	5 **	5 **	5 **	5 **	0.6	2
NYS Groundwater Effluent Limitations (µg/l) (a)	5	5	5	5	5	5	5	0.6	2
NYS Recommended Soil Cleanup Objectives (mg/kg) (b)	1.4	0.7	0.3	0.3	0.8	0.4	0.2	0.1	0.2
US EPA Drinking Water Standards - MCLG/MCL (mg/l) (c)	0/0.005	0/0.005	0.07/0.07	0.1/0.1	0.2/0.2	0.007/0.007	NA/NA	0/0.005	0/0.002
US EPA Drinking Water Health Advisory [1] (mg/l) (c)	NA	NA	0.07	0.1	0.2	0.007	NA	NA	NA
US EPA Ambient Water Quality Criteria (µg/l) (d)	0.8 [2]/8.85 [3]	2.7 [2]/81 [3]	NA/NA	NA/NA	NA/NA	0.057 [2]/3.2 [3]	NA/NA	0.38 [2]/99 [3]	2 [2]/525 [3]
National Ambient Air Quality Standards (µg/m³)	NA	NA	NA	NA	NA	NA	NA	NA	NA
NYS Air Guide 1 (SGC) (µg/m³) (e)	81000	33000	190000	190000*	450000	2000	190000	950	1300
NYS Air Guide 1 (AGC) (µg/m³) (e)	0.075	0.45	1,900	360	1,000	0.02	500	0.039	0.020
OSHA - PEL (ppm)	100	100	200*	200*	350	none	100	50	1
NIOSH - REL (ppm)	Ca	Ca	200*	200*	350 C	Ca	100	1 Ca	Ca
NIOSH - IDLH (ppm)	150 Ca	1000 Ca	1000*	1000*	700	Ca	3000	50 Ca	Ca
ACGIH - TLV (ppm)	25 A3 BEI	50 A5 BEI	200*	200*	350 A4 BEI	5 A4	100 A4	10 A4	1 A1

(a) - NYSDEC Division of Water Technical and Operational Guidance Series (1.1.1), June 1998.
(b) - NYSDEC Technical Administrative Guidance Memorandum 40-46, January 1994.
(c) - Source was http://www.epa.gov/OST/Tools/dwstds.html, revised 4 February 1999.
(d) - 40 Code of Federal Regulations 131.36, August 1995.
(e) - NYSDEC Guidelines For The Control of Toxic Ambient Air Contaminants, 1991.
1 - Exposure over a lifetime.
2 - For consumption of water & organisms.
3 - For consumption of organisms only.
* - Value is for 1,2-Dichloroethylene (total).
** - The principal organic contaminant standard of 5 ug/L applies to this substance (6 NYCRR 700.1)
A1 - Confirmed human carcinogen.
A2 - Suspected human carcinogen.
A3 - Animal carcinogen.
A4 - Not classifiable as a human carcinogen.
A5 - Not suspected as a human carcinogen.
ACGIH - American Conference of Governmental Industrial Hygienists.
AGC - Annual Guideline Concentratoins
BEI - Biological Exposure Indices
C - Ceiling limit.
Ca - Potential carcinogen.
GV - Guidance value
IDLH - Immediately dangerous to life of health
MDL - Method Detection Limit
NA - Not available.
NIOSH - National Institute for Occupational Safety and Health
OSHA - Occupational Safety and Health Association
PEL - Permissible exposure limits
REL - Recommended exposure limits.
SB - Site Background
SGC - Short-term Guideline Concentrations
TLV - Threshold limit value

PCE - Tetrachloroethylene
TCE - Trichloroethylene
1,2-DCE - 1,2-Dichloroethylene
1,1,1-TCA - 1,1,1-Trichloroethane
1,1-DCE - 1,1-Dichloroethylene
1,1-DCA - 1,1-Dichloroethane
1,2-DCA - 1,2-Dichloroethane
VC - Vinyl Chloride

these standards may be used to determine remedial action objectives and/or treatment objectives for effluent waters (i.e., from a groundwater remediation system). Table 7-1 summarizes the standards that apply to the groundwater medium for the COCs.

Discharges to a local injection system (i.e., leaching pools or injection wells) may require a permit or permit equivalent under the State Pollution Discharge Elimination System (SPDES). SPDES permit requirements are presented in 6 NYCRR Part 750.

According to the Nassau County Department of Health (NCDOH), any discharge to a public stormwater system must meet the groundwater standards. A public stormwater collection system in the vicinity of the NCIA off-site area discharges to a retention basin and local sumps where stormwater is recharged to the underlying aquifer. Any discharges to this stormwater recharge system must then meet applicable groundwater criteria.

7.2.2 New York State Groundwater Effluent Limitations (Class GA)

The NYSDEC DOW regulates point source discharges to Class GA groundwater primarily through the use of effluent limitations that have been established statewide. The effluent limitations are set at concentrations that should prevent contaminants from causing an exceedance of the New York State ambient groundwater standards and guidance values. These numerical values are also presented in NYSDEC's TOGS 1.1.1 (NYSDEC 1998) and summarized in Table 7-1.

7.2.3 U.S. Environmental Protection Agency (USEPA) Drinking Water Standards

These federal standards include National Primary Drinking Water Standards (40 Code of Federal Regulations (CFR) Part 141) promulgated under the authority of the Safe Drinking Water Act (SDWA) for the regulation of contaminants in all surface or groundwaters utilized as potable water supplies. The primary standards include both MCLs and Maximum Contaminant Level Goals (MCLGs). MCLs are enforceable standards for specific contaminants based on human health factors, and the technical and economic feasibility of removing the contaminants from the water supply. MCLGs are nonenforceable standards that do not consider the feasibility of contaminant removal. The SDWA also provides for secondary MCLs (40 CFR Part 143) that are nonenforceable guidelines for those contaminants that may adversely affect the aesthetic quality of drinking water, such as taste, color, and odor. The constituents addressed in the SDWA are also addressed in the New York State Groundwater Standards. Table 7-1 summarizes the drinking water standards for the off-site groundwater COCs.

7.2.4 **USEPA Drinking Water Health Advisories**

USEPA Drinking Water Health Advisories are nonenforceable guidelines developed by the USEPA for chemicals that may be encountered in drinking water. USEPA has prepared short-term (1- to 10-day) and long-term (several years to lifetime) health advisories for subchronic effects of contaminants. A drinking water equivalent level (DWEL) is calculated as a lifetime health advisory based on a 2-liter/day water consumption rate for an adult weighing 70-kg. The DWEL is an appropriate guideline for evaluation of contaminant levels in a potable water supply. Table 7-1 presents the applicable DWELs for the NCIA off-site groundwater.

7.2.5 **Federal Ambient Water Quality Criteria**

In accordance with Section 304(a) of the Clean Water Act, EPA has developed the Federal Ambient Water Quality Criteria (AWQC) for priority toxic pollutants. AWQCs are not legally enforceable, but may be referenced by states when developing enforceable water quality standards. AWQCs are available for both the protection of human health from exposure to contaminants in drinking water and for the protection of aquatic life. Table 7-1 summarizes the criteria applicable to the COCs identified in the NCIA off-site groundwater.

7.2.6 **Sewage Discharge Pretreatment Standards**

Federal regulations (40 CFR Part 403) require sewer districts to establish and enforce pretreatment standards for the users of their sewer system. A user is prohibited from discharging waste to the sewer that contains contaminants that exceed the pretreatment standards. The user must treat the waste to meet the pretreatment standards prior to discharging it to the sewer. Pretreatment standards vary by municipality. Since effluent from a remediation system (e.g., treated groundwater) cannot be discharged to the Nassau County Department of Public Works sewer system, sewage pretreatment standards are relevant only to such discharges as small quantities from a pilot study.

7.2.7 New York State Recommended Soil Cleanup Objectives

The New York State recommended soil cleanup objectives have been prepared by NYSDEC in a revised Technical and Administrative Guidance Memorandum (TAGM #4046) issued in November 1994 (NYSDEC 1994). This guidance document outlines the basis and procedure for determining soil cleanup levels at state Superfund sites. Soil cleanup objectives are based on the protection of human health and groundwater quality and are dependent on the total organic carbon (TOC) content of site soils. TAGM #4046 also includes ranges of metals concentrations in native soils of the eastern United States. For the off-site groundwater area, remedial action objectives for soils will be considered only if a groundwater remediation technology can transfer contaminants to overburden soils. These soil objectives are summarized in Table 7-1.

7.2.8 HEAST and IRIS Tables

EPA's Health Effects Assessment Summary Tables (HEAST) and Integrated Risk Information System (IRIS) contain information used in risk assessment calculations, specifically in establishing the health risk of carcinogenic and noncarcinogenic chemicals. The most recent publications are available on the Internet.

7.2.9 Clean Air Act

The Clean Air Act (CAA) was passed in 1977 and governs air emissions resulting from remedial actions at CERCLA sites. National Ambient Air Quality Standards (NAAQS), presented in 40 CFR Part 50, have been promulgated under the CAA for six criteria pollutants, including airborne particulate matter. No specific CAA standards have been promulgated for the off-site groundwater COCs. The CAA is considered a relevant SCG for the NCIA off-site groundwater only to the extent that remedial actions (e.g., groundwater treatment processes) undertaken emit constituents that are regulated by the CAA. The standards for the COCs are summarized in Table 7-1.

7.2.10 New York State Air Guide One

The NYS Air Guide One (AG-1) provides guidance for the control of toxic ambient air contaminants in New York State. The guidelines outlined in this document are applicable to both chemical contaminants directly addressed by Federal or New York State (NYS) regulations and those for which no Federal or state ambient air quality standards exist. These guidelines are primarily intended for use in conjunction with the permitting authority and regulations found in 6 NYCRR Parts 200, 201, 212, and 257. If treatment processes for the off-site groundwater contamination cause an air emission, the activity must comply with the AG-1 guidelines. Table 7-1 lists the short-term and annual guideline concentrations (SGCs and AGCs) for the off-site groundwater COCs.

7.2.11 **Occupational Safety and Health Administration**

The Occupational Safety and Health Administration (OSHA) has promulgated permissible exposure limits (PELs) for a variety of contaminants in air (29 CFR 1910, Subpart Z). The PELs are based on time-weighted average (TWA) concentrations to which workers may be exposed over an 8-hr exposure period without adverse effects. PELs and TWAs are intended for adult workers exposed in an occupational setting, and are not directly applicable to CERCLA (see Section 7.4.1) or NYS inactive hazardous waste disposal sites. The PELs and TWAs may be used as guidance values to determine whether long-term exposures to contaminants in air during remediation activities may pose a health risk to workers. Table 7-1 summarizes the OSHA PELs for the COCs.

7.2.12 **National Institute for Occupational Safety and Health**

The National Institute for Occupational Safety and Health (NIOSH) has developed concentrations for contaminants in air that are immediately dangerous to life or health (IDLH) for individuals in occupational settings. The IDLH is the maximum concentration, in the event of respirator failure, that could be tolerated for 30-min without experiencing any escape-impairing or irreversible health effects. The IDLHs are appropriate only for subchronic exposures to noncarcinogenic compounds or effects of compounds in air. These values are not directly applicable to CERCLA (see Section 7.4.1); however, they may provide guidance concerning the upper bound of safe inhalation exposures to contaminants for on-site workers during remediation. NIOSH also has established recommended exposure limits (RELs) for several contaminants. An REL is generally a time-weighted average based on toxicological and industrial hygiene data. Applicable NIOSH IDLHs and RELs are presented in Table 7-1.

7.2.13 American Conference of Governmental Industrial Hygienists

The American Conference of Governmental Industrial Hygienists (ACGIH) has developed threshold limit values (TLVs) for contaminants in air that are updated annually. The TLV is a time-weighted average concentration under which most people can work consistently for 8 hours per day, over time, and receive no harmful effects. These values should be considered when developing a remediation plan to protect workers during remediation activities. Table 7-1 summarizes the TLVs for the off-site groundwater COCs.

7.3 LOCATION SPECIFIC SCGs

7.3.1 Well Usage Permit

6 NYCRR Part 602 requires that any well installed in Kings, Queens, Nassau, or Suffolk Counties to withdraw water for any purpose other than a public water supply must have a permit if the total capacity of such a well or wells on any one property is in excess of 45 gallons per minute (64,800 gallons per day). This regulation encompasses temporary and permanent dewatering wells. If a remediation alternative is selected that includes groundwater extraction, a permit may need to be obtained to satisfy this regulation.

7.3.2 New York State Protection of Sole Source Aquifer

6 NYCRR Part 370 defines a sole source aquifer as being the principal drinking water source for an area. If contamination were to occur in such a sole source aquifer, it would pose a significant hazard to the health of the public. The Long Island Aquifer System is among those specific sole source aquifers that are listed. This system includes aquifers underlying the counties of Kings, Queens, Nassau, and Suffolk in New York State. Certain remediation activities may be restricted due to the sole source aquifer designation.

7.3.3 Federal Protection of Sole Source Aquifer

The Code of Federal Regulations (40 CFR Part 149) describes the criteria for identifying critical aquifer protection areas pursuant to Section 1427 of the SDWA. Subpart 149.3 includes criteria that define a sole source aquifer and states that programs to reduce or prevent the contamination of sole source aquifers must be implemented when it is reasonably likely that contamination of such aquifers will occur. Certain remediation activities may be restricted due to the sole source aquifer designation.

7.3.4 Article IV of the Nassau County Public Health Ordinance

The intent of Article IV is to prohibit the installation of a private water system in those areas served by a public water system. The NCIA and its surrounding properties are serviced by a public water system, therefore this ordinance prohibits the installation of a new private water system to provide drinking water. For purposes of the exposure pathway analysis (Chapter 8) and the FS (Chapters 9 through 12), and as requested by NYSDEC, it is herein assumed that no private wells exist in areas affected by the NCIA off-site groundwater contamination.

7.4 ACTION SPECIFIC SCGs

7.4.1 Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 was amended by the Superfund Amendment and Reauthorization Act (SARA) of 1986. CERCLA, specifically Section 121 (42 USC Part 9621, Cleanup Standards), states that the selected remedial alternative must attain a cleanup level that is protective of human health and the environment, cost effective, and utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. The extent to which each of the remedial alternatives considered complies with this requirement will be assessed during the detailed evaluation of alternatives (Chapter 12 of FS).

7.4.2 Resource Conservation and Recovery Act (RCRA) and New York State Hazardous Waste Regulations

The selected remedial alternative(s) may include activities that require the generation, storage, treatment, transport, and/or disposal of hazardous waste. A waste can be identified as hazardous under two categories: 1) a waste is a "listed" hazardous waste if it is specifically listed in 40 CFR Part 261 or 6 NYCRR Part 371, or 2) a waste is a "characteristically" hazardous waste if it exhibits the characteristic of ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR Part 261 or 6 NYCRR Part 371. Handling of waste soil or groundwater that is determined to be "hazardous" must be performed in accordance with the federal hazardous waste regulations (40 CFR Parts 260-268) promulgated under the Resource Conservation and Recovery Act (RCRA), as well as New York State hazardous waste regulations (6 NYCRR Parts 364 and 370-376).

At the NCIA off-site areas, soil and groundwater that are removed as part of remediation may be considered to be listed hazardous wastes (i.e., containing spent halogenated solvents, as per 40 CFR Part 261, Subpart D). Soil and groundwater that are removed from the ground may be considered to be characteristically hazardous based on the constituent concentrations found in representative samples. If concentrations in samples exceed the regulatory level for the toxicity characteristic (TC) limit, the waste is considered a characteristically hazardous waste and must be treated or disposed of as such. Table 7-2 summarizes some of the EPA classifications and regulatory levels for hazardous wastes that may be generated in the off-site area during the remedial action phase.

Federal and state land disposal restrictions (LDRs) (40 CFR Part 268 and 6 NYCRR Part 376, respectively) identify hazardous wastes that are restricted from land disposal. A hazardous waste may be land disposed only if its constituent concentrations or an extract of the waste does not exceed regulatory constituent concentrations. Hazardous wastes containing halogenated organic compounds (HOCs) in concentrations greater than or equal to 1,000 ppm are restricted from land disposal. However, a hazardous waste may be treated to reduce its constituent concentrations below the regulatory LDR limits and subsequently be land disposed. If a soil is found to be characteristically hazardous by exceeding the TC limit, it must be disposed of at an approved hazardous waste facility or treated on-site. If treatment or facility standards are achieved, the soil is no longer subject to hazardous waste requirements and can be land disposed at a non-hazardous off-site facility.

Contaminated groundwater that is pumped to the surface is subject to similar regulations if it is found to be characteristically hazardous during the remedial action. As with soil, groundwater that exhibits the TC is subject to the same treatment standards as the characteristic waste with which it is contaminated. Groundwater containing 1,000 ppm or greater HOCs is prohibited from land disposal. If treatment standards are met, the groundwater can be discharged on land. Transportation of hazardous wastes must be

TABLE 7-2

MAXIMUM TOXICITY CHARACTERISTIC CONCENTRATIONS

New Cassel Industrial Area Off-site Groundwater

EPA Hazardous Waste Number	Contaminant	RCRA Hazardous Waste Criteria * (mg/l)
D028	1,2-Dichloroethane	0.5
D029	1,1-Dichloroethylene	0.7
D039	Tetrachloroethylene	0.7
D040	Trichloroethylene	0.5
D043	Vinyl chloride	0.2

* - 40 CFR part 261, subpart C.

conducted in accordance with all applicable regulations, including 40 CFR Part 263 and 6 NYCRR Part 372.

7.4.3 State Pollution Discharge Elimination System

New York State regulations (6 NYCRR Parts 750-758) prohibit discharge of any pollutant to a water body, including groundwater, without first meeting the state pollutant discharge elimination system (SPDES) requirements. NYSDEC typically requires periodic sampling to demonstrate satisfactory compliance with the SPDES discharge standards. For the NCIA off-site groundwater, achieving SPDES requirements and periodic sampling would be necessary if a remediation system produced a liquid waste stream that required disposal to groundwater or the local stormwater collection system.

7.4.4 Underground Injection Control

EPA's Underground Injection Control (UIC) Program under the SDWA regulates discharges to the subsurface to protect underground sources of drinking water from contamination. A remediation alternative containing a discharge component must comply with 40 CFR Parts 124, 144, 145, and 146, which describe the regulatory requirements of EPA's UIC program. Requirements include permitting and limitations on contaminant concentrations.

7.4.5 EPA Presumptive Remedies

Since Superfund's inception in 1980, the remedial and removal programs have found that certain categories of sites have similar characteristics, such as types of contaminants present, types of disposal practices, or how environmental media are affected. Based on information acquired from evaluating and cleaning up these sites, the Superfund program is undertaking an initiative to develop presumptive remedies to accelerate future cleanups at these types of sites. Presumptive remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. The objective of the presumptive remedies initiative is to use the program's past experience to streamline site investigation and speed up selection of cleanup actions.

For the NCIA off-site groundwater, the EPA presumptive remedy titled "Presumptive Response Strategy and Ex-situ Treatment Technologies for Contaminated Groundwater at CERCLA Sites" (EPA 1996), which identifies presumptive technologies for the ex-situ treatment component of a groundwater remedy that are expected to be used for sites where extraction and treatment is part of the remedy, should be considered in formulating and selecting remediation alternatives. For treatment of dissolved organic contaminants, the presumptive technologies include air stripping, granular activated carbon (GAC), chemical/ultraviolet light oxidation, and aerobic biological reactors. For treatment of dissolved inorganic contaminants, the presumptive technologies include chemical precipitation, ion exchange/adsorption, electrochemical methods, and aeration. For treatment of both organic and inorganic constituents, a combination of the technologies listed above is recommended.

EPA's presumptive remedies will be considered in the development and screening of technologies phase of the FS and in developing the remedial alternatives for the NCIA off-site groundwater contamination.

7.4.6 EPA Guidance on Remedial Action for Contaminated Groundwater at Superfund Sites

This EPA guidance (EPA/540/G-88/003) provides information to make key decisions in developing, evaluating, and selecting groundwater remedial actions at Superfund sites (EPA 1988). This document focuses on policy issues and the decision-making approach and highlights key considerations that should be addressed during the remedy selection process. Guidance offered by this document will be considered in developing remedial alternatives.

7.4.7 EPA Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA

This EPA guidance (EPA/540/G-89/004) provides the methodology that the Federal Superfund program has established for characterizing the nature and extent of the risks posed by uncontrolled hazardous waste sites and for evaluating potential remedial options (EPA 1988). This document will be used as a guide in preparing the FS for the NCIA off-site groundwater.

7.4.8 **Risk Assessment Guidance for Superfund**

The Risk Assessment Guidance for Superfund (Volume I, Human Health Evaluation Manual [Part A]) was developed by EPA to provide guidance for developing health risk information at Superfund sites and to support CERCLA's requirement to protect human health and the environment (EPA 1989). This guidance was referenced in preparing the health exposure pathway analysis (Chapter 8).

7.4.9 **NYSDEC Selection of Remedial Actions at Inactive Disposal Sites**

As presented in TAGM HWR-90-4030, NYSDEC's guidance establishes a hierarchy of remedial technologies for inactive hazardous waste disposal sites in New York State and describes the preliminary screening and detailed analysis of remedial alternatives. (NYSDEC 1990). The guidelines set forth in this TAGM will be used in developing the NCIA off-site groundwater FS.

CHAPTER 8

HEALTH EXPOSURE PATHWAY ANALYSIS

8.1 INTRODUCTION

A health exposure pathway analysis was conducted for the NCIA off-site groundwater (in general terms, the contaminated groundwater situated downgradient of the NCIA, south of Old Country Road and Grand Boulevard) to identify and evaluate potential baseline exposure pathways to human health from groundwater contamination originating from the NCIA sites. Only off-site groundwater is evaluated in this exposure pathway analysis; individual NCIA sites are not assessed. The exposure pathway analysis was completed in accordance with EPA's Risk Assessment Guidance for Superfund – Volume I: Human Health Evaluation Manual (EPA 1989a). Results of this health exposure pathway analysis were used to determine the need for groundwater remedial actions and to help establish remedial action objectives for the off-site contaminated groundwater.

This exposure pathway analysis involved the following steps:

- Collection and evaluation of available groundwater data obtained from remedial investigation (RI) activities;
- Identification of potential contaminants of concern (COCs) for NCIA off-site groundwater to be evaluated in a qualitative assessment of exposure;
- Screening of the potential COCs via concentration-toxicity calculations;
- Investigation of potential pathways for human exposure to off-site groundwater contaminants;
- Toxicity assessment/hazard identification for the selected COCs; and
- Development of conclusions for potential exposures to groundwater COCs at locations downgradient of the NCIA.

These steps are described in detail in the following sections. While this exposure pathway analysis does not quantify the risks associated with the exposures (that is done in risk assessment), a qualitative evaluation of the uncertainties involved in the exposure pathway analysis procedures is presented here.

This health exposure pathway analysis is organized into the following sections:

8.1 Introduction
8.2 Data Collection and Evaluation
8.3 Exposure Assessment
8.4 Toxicity Assessment
8.5 Uncertainty Analysis
8.6 Conclusions

8.2 DATA COLLECTION AND EVALUATION

8.2.1 Collection of Relevant Site Data

RI analytical data obtained for the off-site groundwater were evaluated for use in the health exposure pathway analysis. In accordance with EPA guidance (EPA 1989a), only positive sample results were used in this pathway exposure analysis. All tentatively identified compounds (TICs) were eliminated from further consideration, as these compounds were not positively identified. In general, the TICs detected were present at low concentrations and were not assumed to pose a significant risk to humans. A description of all groundwater analytical results is included in Chapter 5 of this report.

To appropriately focus the health exposure pathway analysis, a subset of the contaminants detected at each site, referred to as COCs, was selected for further evaluation. COCs are those compounds that pose the greatest potential public health risk at a particular site based on the concentrations detected and the relative toxicity of the compounds. Sections 8.2.2 and 8.2.3 discuss the identification and selection of COCs, respectively, for the NCIA off-site groundwater contaminant plumes.

8.2.1.1 Overview of RI Data Collection Activities. Monitoring well and hydropunch groundwater sampling data from the RI were used in the analysis of COCs for this human health exposure pathway analysis. To focus the evaluation on the off-site groundwater affected by the NCIA sites, data from monitoring wells and hydropunches located south of Old Country Road and Grand Boulevard were used. Data from groundwater samples collected within each of the three existing, distinct off-site plumes were combined in this exposure pathway analysis; plume-specific data evaluations were not conducted.

Monitoring well data from three recent RI sampling events (April 1999, August 1999, and January 2000) were evaluated. In order to evaluate the most current groundwater conditions in this pathway analysis, if an off-site monitoring well was sampled during more than one of the above-mentioned events, the most recent groundwater data were retained. Data from a total of 26 monitoring wells were used in the potential COC evaluation. The identification numbers and depths (ft bgs) of the monitoring wells included in the pathway analysis are noted below. The wells are categorized by sampling event.

April 1999 (1 monitoring well): N-10475 (57)

August 1999 (12 monitoring wells):

N-9939 (74)	N-11849 (60)
N-10329 (57)	N-11852 (100)
N-10472 (62)	N-11858 (60)
N-10476 (130)	N-11859 (60)
N-10479 (40)	N-11861 (60)
N-11848 (60)	N-11862 (60)

January 2000 (13 monitoring wells):

EW-1B (164)	NRMW-4 (70)
EW-1C (516)	N-10474 (60)
EW-2B (142)	N-10477 (57)
EW-2C (514)	N-10478 (121)
NRMW-1 (70)	N-11851 (65)
NRMW-2 (70)	N-11860 (60)
NRMW-3 (70)	

A total of 38 hydropunch samples collected in January and February 2000 from four off-site locations (GWHP-1, -2, -3, and –4) were also used in the evaluation of potential off-site groundwater COCs. The hydropunch sample identification numbers and sample depth intervals (ft bgs) are listed below.

GWHP-1 (60-62)	GWHP-2 (58-60)	GWHP-3 (58-60)	GWHP-4 (58-60)
GWHP-1 (70-72)	GWHP-2 (70-72)	GWHP-3 (68-70)	GWHP-4 (68-70)
GWHP-1 (80-82)	GWHP-2 (78-80)	GWHP-3 (78-80)	GWHP-4 (78-80)
GWHP-1 (90-92)	GWHP-2 (94-96)	GWHP-3 (88-90)	GWHP-4 (88-90)

GWHP-1 (98-100)	GWHP-2 (100-102)	GWHP-3 (98-100)	GWHP-4 (108-110)
GWHP-1 (108-110)	GWHP-2 (108-110)	GWHP-3 (108-110)	GWHP-4 (118-120)
GWHP-1 (118-120)	GWHP-2 (118-120)	GWHP-3 (118-120)	GWHP-4 (138-140)
GWHP-1 (128-130)	GWHP-2 (128-130)	GWHP-3 (128-130)	GWHP-4 (148-150)
GWHP-1 (138-140)	GWHP-2 (138-140)	GWHP-3 (138-140)	
GWHP-1 (148-150)	GWHP-2 (148-150)	GWHP-3 (148-150)	

The locations of all monitoring wells and hydropunches are shown in Chapter 3 of this report. A complete discussion of RI data collection activities is also included within Chapter 3 of this report.

8.2.2 Identification of Potential Contaminants of Concern

Three criteria were used to identify the potential COCs for the NCIA off-site groundwater contamination. The first was the comparison of positive sample results to applicable New York State standards; chemicals exceeding standards were given higher priority for selection as COCs. All groundwater sample results were compared to NYSDEC Guidance Values for Class GA groundwater. The degree to which a chemical concentration exceeded the standard or guidance value was also taken into consideration as part of this criterion. For instance, if a chemical concentration exceeded the applicable standard by several orders of magnitude, the chemical was typically given more weight for consideration as a potential COC than a chemical that minimally exceeded its standard.

The second criterion was an evaluation of the frequency of chemical detection; the higher the frequency, the higher the priority given for consideration as a COC. If a chemical was detected in the groundwater samples collected, more than 50 percent of those detected values typically had to exceed the standard for that chemical to be given further consideration in the COC selection process.

The third criterion was whether the chemical was related to suspected discharges that were reported to have historically occurred at the properties/sites within the NCIA (i.e., discharges of wastes to dry wells or sanitary drains). Contaminants possibly associated with discharges or other site activities were given special consideration.

Analytical results for the 64 groundwater samples (26 monitoring well samples and 38 hydropunch samples) considered in this exposure pathway analysis are summarized in Table 8-1. All samples were analyzed for VOCs. As shown in Table 8-1, nine potential

COCs were identified in the off-site groundwater. 1,1-DCA, 1,1-DCE, 1,2-DCA, 1,2-DCE (total), 1,1,1-TCA, 1,1,2-TCA, PCE, TCE, and vinyl chloride were retained as potential COCs based on frequencies of detection and detected concentrations that were in exceedence of NYS Class GA groundwater standards. Although 1,2-DCA and vinyl chloride were each detected in only 3 of the 64 groundwater samples evaluated, they were retained as potential COCs since all of the detected concentrations were above the respective Class GA standard. These two compounds are also breakdown products of some of the other potential COCs identified. 1,1,2-TCA was only detected in 5 of 64 samples; however, since this compound exceeded the groundwater criterion in 80% of the samples that had detected concentrations, it was also retained for further analysis.

8.2.3 Concentration-Toxicity Screening

A concentration-toxicity screening of the preliminary lists of COCs for the NCIA off-site groundwater contamination was conducted to develop a final list of COCs. This screening procedure identifies those contaminants in the off-site groundwater that are most likely to substantially contribute to the human health risk resulting from exposure to that matrix. This assessment is conducted by calculating a chemical score (R_i) for each potential groundwater COC according to the following equations:

- Noncarcinogenic effects:

$$R_i = \frac{\text{Maximum contaminant concentration}}{RfD}$$

where RfD equals the reference dose.

- Carcinogenic effects:

$$R_i = \text{Maximum contaminant concentration x slope factor}$$

The maximum contaminant concentration used in these equations is the maximum detected concentration for each COC identified in the groundwater data that were reviewed, as shown in Table 8-1. The slope factors and reference doses (RfDs) used in these equations were obtained from the EPA's on-line database (updated 13 April, 2000) or HEAST Report (EPA 1997). The oral RfD for a contaminant was used to calculate the chemical score unless the inhalation value (reference concentration, RfC or RfD_i) was more conservative (i.e., smaller than the oral value). The inhalation slope factor for

TABLE 8-1

POTENTIAL CONTAMINANTS OF CONCERN IN GROUNDWATER
NCIA Off-Site Groundwater

PARAMETER	FREQUENCY OF DETECTION [1]	RANGE OF DETECTED CONCENTRATIONS (ug/l)	NYSDEC Class GA Objectives [2] (ug/l)	PERCENTAGE ABOVE STANDARD [3]	POTENTIAL COC
VOLATILE ORGANICS (mg/kg)					
Methylene chloride	5/64	1 - 17	5	40%	No
Acetone	3/64	1 - 6	50	0%	No
Carbon Disulfide	1/64	2 - 2	NA	0%	No
Chloroethane	1/64	2 - 2	5	0%	No
Chloroform	12/64	1 - 8	7	17%	No
1,1-DCA	19/64	1 - 880	5	58%	Yes
1,1-DCE	17/64	2 - 1700	5	71%	Yes
1,2-DCE (total)	11/64	1 - 94	5	55%	Yes
1,2-DCA	3/64	4 - 22	0.6	100%	Yes
TCE	22/64	2 - 1800	5	82%	Yes
1,1,1-TCA	33/64	1 - 820	5	58%	Yes
1,1,2-TCA	5/64	1 - 8	1	80%	Yes
PCE	23/64	1 - 1100	5	74%	Yes
1,3-Dichlorobenzene	1/64	4 - 4	3	100%	No
1,4-Dichlorobenzene	1/64	1 -1	3	0%	No
Vinyl Chloride	3/64	5 - 6	2	100%	Yes
Toluene	1/64	1 -1	5	0%	No
Xylene (total)	5/64	2 - 3	5	0%	No

1 - Only compounds that were detcted in at least one sample are included.

2 - NYSDEC Division of Water Technical and Operational Guidance Series (1.1.1), June 1998.

3 - Percent of detected values that are above the standard.

carcinogenic effects was used unless no inhalation value was available or the oral slope factor was more conservative (i.e., larger than the inhalation slope factor).

Following the calculations of chemical scores for both the noncarcinogenic and the carcinogenic effects for each potential groundwater COC, the chemical scores were summed (R_t). Chemical scores for noncarcinogenic and carcinogenic effects were summed separately. A relative risk for each contaminant was then calculated by dividing the contaminant's chemical score by the total of the noncarcinogenic or carcinogenic chemical scores (as appropriate), as follows:

$$Relative\ risk = \frac{R_i}{R_t}$$

This calculated relative risk is not a quantitative assessment of the risk posed by a particular contaminant and is used only for comparative purposes in the concentration-toxicity screening. The concentration-toxicity screening calculations for the off-site groundwater are included in Table 8-2.

Based on the calculated relative risks for the off-site groundwater contaminants, those chemicals that did not contribute substantially to the overall risk to human health from exposure to that matrix (i.e., those contaminants presenting a relative risk equal to or less than 0.01, or 1.0% of the total risk) were eliminated. Table 8-3 summarizes the final list of COCs, including both carcinogenic and noncarcinogenic effects, that were retained based on the concentration-toxicity screening evaluation.

8.3 EXPOSURE ASSESSMENT

The purpose of an exposure assessment is to identify exposure pathways by which humans may contact the groundwater COCs. Potential exposure pathways were identified for both "current use" and "future use" scenarios.

8.3.1 Identification and Screening of Exposure Pathways

An exposure pathway consists of a source and mechanism of contaminant release, a receiving matrix, a point of potential human contact with the contaminated matrix (i.e., exposure point), and an exposure route (i.e., inhalation, ingestion, or dermal contact). If an exposure pathway is not complete because it does not include a receiving matrix, a

TABLE 8-2
CONCENTRATION-TOXICITY SCREENING FOR CONTAMINANTS OF CONCERN
GROUNDWATER SAMPLES
NCIA Off-Site Groundwater

ANALYTE	MAXIMUM CONCENTRATION DETECTED (ug/l)	SLOPE FACTOR[a] $(mg/kg/day)^{-1}$	REFERENCE DOSE[b] (mg/kg/day)	CHEMICAL SCORE (RI)	RI/Rt
NONCARCINOGENIC					
VOCs:					
Vinyl Chloride	6	-	NV	-	-
1,1-DCE	1700	-	9.00E-03	1.89E+05	3.0E-01
1,1-DCA	880	-	1.00E-01	8.80E+03	1.4E-02
1,2-DCE (total)	94	-	9.00E-03	1.04E+04	1.6E-02
1,2-DCA	22	-	1.40E-03	1.57E+04	2.5E-02
1,1,1-TCA	820	-	2.80E-01	2.93E+03	4.6E-03
1,1,2-TCA	8	-	4.00E-03	2.00E+03	3.1E-03
TCE	1800	-	6.00E-03	3.00E+05	4.7E-01
PCE	1100	-	1.00E-02	1.10E+05	1.7E-01
CARCINOGENIC					
VOCs:					
Vinyl Chloride	6	1.90E+00	-	1.14E+01	1.0E-02
1,1-DCE	1700	6.00E-01	-	1.02E+03	9.2E-01
1,1-DCA	880	NV	-	-	-
1,2-DCE (total)	94	NV	-	-	-
1,2-DCA	22	9.10E-02	-	2.00E+00	1.8E-03
1,1,1-TCA	820	NV	-	-	-
1,1,2-TCA	8	5.70E-02	-	4.56E-01	4.1E-04
TCE	1800	1.10E-02	-	1.98E+01	1.8E-02
PCE	1100	5.20E-02	-	5.72E+01	5.1E-02

NV - No value available.
a - Slope factor based on inhalation unit risk unless oral unit risk more conservative. Source: EPA's Integrated Risk Information System (IRIS) (January 2000 update) or the Health Effects Assessment Summary Tables (HEAST) Report.
b - Chronic RfD for ingestion unless inhalation value more conservative. Source: EPA's Integrated Risk Information System (IRIS) (January 2000 update) or the Health Effects Assessment Summary Tables (HEAST) Report

TABLE 8-3

POTENTIAL CONTAMINANTS OF CONCERN FOR INCLUSION IN THE HEALTH EXPOSURE ASSESSMENT (Off-Site Groundwater)

(After the Concentration-Toxicity Screening)

LOCATION	NONCARCINOGENIC EFFECTS	CARCINOGENIC EFFECTS
Off-Site Groundwater		
	1,1 Dichloroethene 1,1 Dichloroethane 1,2 Dichloroethene (total) 1,2 Dichloroethane Trichloroethene Tetrachloroethene	Vinyl Chloride 1,1 Dichloroethene Trichloroethene Tetrachloroethene

point of potential human contact, or an exposure route, then no risk exists. Potential exposure pathways associated with the off-site groundwater plumes for current and future land use scenarios are discussed. Potential exposure pathways that have been identified and screened for the off-site contamination are included in Table 8-4 (current land use scenario) and Table 8-5 (future use scenario).

The pathways have been arranged according to locations of the off-site groundwater that were determined to be contaminated (i.e., plumes) based on recent environmental monitoring conducted (contaminant plume maps are included in Chapter 5 of this report). The release source and mechanism by which the receiving groundwater likely became contaminated are then identified, followed by the exposure points and routes by which humans may realistically encounter the COCs in the off-site groundwater. The potential exposure pathways were then evaluated (screened) to identify any complete pathway (refer to Tables 8-4 and 8-5).

The current off-site land uses in locations downgradient of the NCIA are based on the existing residential, commercial, and institutional zoning of the properties. The future land use scenario is based on the presumption of continued use of these properties as presently zoned and also considers remedial activities that may take place to address the groundwater contamination at specific off-site locations.

Although source control and groundwater remedies have been proposed at individual sites within the NCIA, the future land use scenario in this pathway analysis does not include changes in the off-site contaminant plumes that may occur as a consequence of these remedial activities in the NCIA. This is because of uncertainties associated with the implementation timeframes and effectiveness of the proposed NCIA remedies. Thus, the location and extent of the off-site groundwater contaminant plumes for the current and future land use scenarios are identical in this pathway analysis.

8.3.1.1 Current Land Use Scenario.

Groundwater contamination originating from the sites/properties within the NCIA has been traced to off-site early warning monitoring wells and two potable supply wells (located approximately 700 ft south of Old Country Road) in the Bowling Green Water District. All of the off-site groundwater contamination, based on data from the RI, is within the Bowling Green Water District, and it is assumed that no contamination has migrated to downgradient areas which are not serviced by Bowling Green wells. While

Table 8-4
SCREENING OF POTENTIAL EXPOSURE PATHWAYS
CURRENT LAND USE SCENARIO
NCIA Off-Site Groundwater

RECEIVING MATRIX	RELEASE SOURCE	RELEASE MECHANISM	EXPOSURE POINT	EXPOSURE ROUTES	PATHWAY RETAINED?	EXPOSURE TIMEFRAME	SCREENING COMMENTS
Groundwater	Historic discharge of wastes to dry wells/on-site disposal systems at NCIA sites.	Leaching/ groundwater migration.	Off-Site (south of Old Country Road and Grand Boulevard).	Inhalation; Ingestion; Dermal Contact.	No	Long-Term	Exposure routes to off-site residents, workers, and visitors exist via potable (tap) water; however, exposure pathway not retained because potable water treated prior to consumption.

Table 8-5
SCREENING OF POTENTIAL EXPOSURE PATHWAYS
FUTURE LAND USE SCENARIO
NCIA Off-Site Groundwater

RECEIVING MATRIX	RELEASE SOURCE	RELEASE MECHANISM	EXPOSURE POINT	EXPOSURE ROUTES	PATHWAY RETAINED?	EXPOSURE TIMEFRAME	SCREENING COMMENTS
Groundwater	Historic discharge of wastes to dry wells/on-site disposal systems at NCIA sites.	Leaching/ grounwater migration.	Off-Site (south of Old Country Road and Grand Boulevard).	Inhalation; Ingestion; Dermal Contact.	No	Short-Term; Long-Term	Short-term exposures to construction and remediation workers may exist, but pathway not retained because engineering controls can be implemented. Potential future inhalation exposure route to off-site residents, workers, and visitors may exist if in-situ treatment system established (via off-gas), but pathway not retained because engineering controls can be implemented. Future exposure routes to off-site residents, workers, and visitors exist via potable (tap) water; however, exposure pathway not retained because treatment of groundwater prior to potable water distribution is expected to continue.

potential exposures (ingestion, inhalation, and dermal contact) via potable water (tap water) for residents, workers, and visitors of the NCIA off-site area have been identified, these exposure pathways are incomplete. Institutional controls (water treatment via air stripping of VOCs and granular activated carbon filtration) at the Bowling Green supply wells remove the contaminants from the groundwater prior to distribution in the public drinking water supply thereby eliminating this potential exposure route.

Since, under Article IV (1987) of the Nassau County Public Health Ordinance, the installation of private water systems/wells in areas served by an existing public water system is prohibited, it was assumed that potential exposures to groundwater COCs via private wells does not exist in the off-site area. In addition, at the request of NYSDEC it was presumed that no private wells exist in the NCIA or in locations downgradient within the area serviced by the Bowling Green Water District.

Finally, groundwater in the off-site area exists at depths (approximately 50 to 55 ft bgs) that do not likely present exposure pathways for construction or utility workers, as excavation for these activities is likely to occur only in the upper unsaturated zone. Therefore, the contaminated off-site groundwater was not considered as a current exposure medium.

8.3.1.2 Future Land Use Scenario.

Individuals involved in future drilling and excavation for implementation of remediation systems may have short-term exposures to contaminated groundwater. However, the exposure pathway for remediation workers is assumed to be eliminated through the use of engineering controls, personal protective equipment, and appropriate site health and safety monitoring. Off-site groundwater is not considered to present a complete exposure pathway in the future for routine utility or construction work because, as discussed above for the current land use scenario, the groundwater contamination is at substantially greater depths than those at which these types of work are expected to occur. Although it is also possible that inhalation exposure routes for groundwater COCs may exist in the future (i.e., inhalation of off-gas from an in-situ groundwater treatment system), it is assumed that engineering controls will be implemented as needed, and no future exposure pathways will exist for area residents, workers, and visitors.

As noted in the current land use scenario, groundwater contamination has been traced to off-site early warning monitoring wells and two potable supply wells in the Bowling

Green Water District. For the future scenario, it was assumed that the extent of the off-site groundwater contamination will be completely within the Bowling Green Water District; that is, it is assumed that no contamination will have migrated to downgradient areas which are not serviced by Bowling Green wells. While potential exposure routes (ingestion, inhalation, and dermal contact) via contaminated potable water may exist, institutional controls are expected to be continually implemented into the future at the Bowling Green supply wells to remove the groundwater contaminants prior to distribution of the water in the public drinking water supply. It is also assumed that no private wells will be installed in the Bowling Green Water District at locations south of the NCIA in the future, as per Article IV of the Nassau County Public Health Ordinance. Thus, no future exposure pathway to off-site groundwater contamination was identified.

8.4 TOXICITY ASSESSMENT

This section discusses the currently documented health effects that have been associated with exposure to the site COCs (1,1-DCA, 1,1-DCE, 1,2-DCE, 1,2-DCA, PCE, TCE, vinyl chloride).

8.4.1 1,1-Dichloroethane (1,1-DCA)

1,1-DCA is a colorless, oily liquid with a chloroform-like odor. 1,1-DCA is often used as a solvent and cleaning and degreasing agent as well as in organic synthesis as an intermediate. Synonyms for 1,1-DCA include; asymmetrical dichloroethane, ethylidene chloride, and 1,1 ethylidene dichloride. Routes of entry include inhalation, ingestion, and skin and eye contact. 1,1-DCA can affect you when breathed in. It may damage the developing fetus. Exposure can cause drowsiness, unconsciousness, and death. High exposure may damage the liver or kidneys. Contact can cause eye and skin irritation with eye burns. Long-term exposure can cause thickening and cracking of skin. 1,1-DCA is a highly flammable liquid and a dangerous fire hazard and should never be used near combustion sources. The highly toxic phosgene gas can be formed if 1,1-DCA is used near welding (Sittig 1991).

In pure form 1,1-DCA reaches its flash point at 2°F. At 68°F 1,1 DCA is 0.04% soluble in water and has a vapor pressure of 182 mm Hg. The OSHA permissible exposure limit for 1,1-DCA is 100 ppm (NIOSH 1997).

8.4.2 1,1- Dichloroethylene (1,1-DCE)

1,1-DCE is a volatile liquid, with a mild sweet odor resembling that of chloroform. 1,1-DCE is used to manufacture polyvinylidene copolymers. Synonyms for 1,1-DCE include vinylidene chloride, and 1,1-dichloroethene. A common route of entry is the inhalation of the vapor, but 1,1-DCE can also pass through skin. 1,1-DCE is a possible human carcinogen. It may damage the developing fetus and cause reproductive damage in males. Exposure can irritate the eyes, nose, and throat. Contact can irritate and burn the eyes and skin. High levels cause a "drunken" feeling that leads to unconsciousness. Repeated exposures may damage the liver, kidneys, and lungs. It is a highly flammable and reactive chemical, and a dangerous fire and explosion hazard (Sittig 1991).

In pure form 1,1-DCE reaches its flash point at -2°F. At 68°F 1,1-DCE is 0.04% soluble in water and has a vapor pressure of 500 mm Hg. OSHA has not published a permissible exposure limit for 1,1-DCE (NIOSH 1997).

8.4.3 1,2-Dichloroethylene (1,2-DCE)

1,2-DCE is used as a solvent for waxes, resins and acetylcellulose. It is also used in the extracction of rubber, as a refrigerant, in the manufacture of pharmaceuticals, and in the extraction of oils and fats from fish and meat. Synonyms for 1,2-DCE include: acetylene dichloride, sym-dichloroetylene, and 1,2 dichloroethene. 1,2-DCE exists in two isomers, cis and trans, with variations in toxicity between these two forms. The routes of entry into the body are via the inhalation of the vapor, by ingestion, and by skin and eye contact. The respiratory system, the eyes, and the central nervous system are greatly affected by 1,2-DCE. As a liquid, it can act as a primary irritant, producing dermatitis and irritation of mucous membranes. Symptoms of acute exposure to high concentrations include dizziness, nausea, and frequent vomiting, and central nervous system intoxication similar to that caused by alcohol (Sittig 1991).

In pure form 1,2-DCE reaches its flash point at 36-39°F. At 68°F 1,2-DCE is 0.4% soluble in water and has a vapor pressure of 180-265 mm Hg. The OSHA permissible exposure limit for 1,2-DCE is 200 ppm (NIOSH 1997).

8.4.4 1,2-Dichloroethane (1,2-DCA)

1,2-DCA is widely used in the manufacture of ethylene glycol, polyvinyl chloride, nylon, viscose rayon, styrene-butadiene rubber, and various plastics. It is a solvent for resin, asphalt, bitumen, rubber, cellulose acetate, and paint; a degreaser in the engineering, textile, and petroleum industries; and an extracting agent for soybean oil and caffeine. It is also used as an antiknock agent in gasoline, a pickling agent, a fumigant, and a dry cleaning agent. Synonyms for 1,2-DCA include ethylene dichloride, ethylene chloride, and glycol dichloride. 1,2-DCA is a colorless, flammable liquid which has a pleasant odor (Sittig 1991).

Routes of entry include inhalation of the vapor, skin absorption of the liquid, ingestion, and eye contact. Short-term exposures via the inhalation route may cause dizziness, nausea, and vomiting. Inhalation exposures to elevated concentrations may cause trembling, headaches, abdominal cramps, liver and kidney damage, fluid build-up in the lungs, coma, and death. Long-term exposure may cause eye, nose, and throat irritation,nausea, vomiting, loss of appetite, nerve damage, and liver and kidney damage. 1,2-DCA is known to cause cancer in laboratory animals. The OSHA permissible exposure limit for 1,2-DCA is 50 ppm (NIOSH 1997).

8.4.5 Tetrachloroethylene (PCE)

PCE is a clear, colorless, nonflammable liquid with a characteristic odor. PCE is a widely used solvent with particular use as a dry cleaning agent, a degreaser, a chemical intermediate, and a fumigant. Synonyms for PCE include: perchloroethylene, carbon dichloride, Ethylene tetrachloride, perclene, and tetrachloroethene. Routes of entry include inhalation of vapor, percutaneous absorption of liquid, ingestion, skin, and eye contact. Short term inhalation exposure can cause irritation of nose, mouth and throat, dizziness, headaches, and lightheadedness. Short term inhalation exposures at elevated levels can cause loss of muscle control, difficulty breathing, irritability, tremors, convulsions, paralysis, heart irregularities and death. Long term inhalation exposures have been reported to cause headaches, sleeplessness, abdominal pains, skin infection, kidney and liver damage, fluid in the lungs and coma. Skin exposure can cause dry, scaly skin, a mild burning sensation, redness and inflammation. Eye exposure causes burning and irritation. Ingestion can cause nausea, vomiting, diarrhea, weakness and loss of muscle control (Sittig 1991).

In pure form PCE at 68°F, is 0.02% soluble in water and has a vapor pressure of 14 mm Hg. The OSHA permissible exposure limit for PCE is 100 ppm (NIOSH 1997).

8.4.6 Trichloroethylene (TCE)

TCE is a colorless, nonflammable, noncorrosive liquid with a sweet odor. It has been used as a solvent for vapor degreasing, dry cleaning, extracting caffeine from coffee and in the production of pesticides, waxes, resins, paints, and varnishes. Synonyms for TCE include: trichloroethene, ethylene trichloride, and ethinyl trichloride. The short-term effects of exposure to low levels of TCE include headaches, sleepiness, nausea, vomiting, dizziness, and coughing. Long-term exposure effects include giddiness, nervous exhaustion, and an increased sensitivity to alcohol. Exposure to higher concentrations can alter the heart rate. Repeated dermal contact can cause excessive dryness, cracking, burning, and loss of the sense of touch or temporary paralysis of the fingers. Most of these effects cease after the exposure has stopped. The routes of entry into the body are through inhalation, ingestion, and skin and eye contact (Sittig 1991).

In pure form TCE at 68°F, is 0.0001% soluble in water and has a vapor pressure of 58 mm Hg. The OSHA permissible exposure limit is 100 ppm (NIOSH 1997).

8.4.7 Vinyl Chloride

Vinyl chloride is a flammable gas at room temperature, and is usually encountered as a cooled liquid. The colorless liquid forms a vapor which has a pleasant, ethereal odor. Synonyms for vinyl chloride include; chloroethylene, chloroethene, and monochloroethylene. Vinyl chloride is used in the manufacture of polyvinyl chloride and other resins. Route of entry into the body is through inhalation. Exposure can cause a feeling of intoxication, tiredness, drowsiness, abdominal pain, numbness, pains in joints, coughing, sneezing, irritability, and loss of appetite and weight. Long term exposure may cause club-like swelling and shortening of finger tips, thickened skin, and damage to bones and joints of arms and legs. Vinyl chloride has caused liver cancer in occupationally exposed individuals (Sittig 1991).

In pure form vinyl chloride at 68°F, is 0.1% soluble in water and has a vapor pressure of 3.3 atm. The OSHA permissible exposure limit is 1 ppm (NIOSH 1997).

8.5 UNCERTAINTY ANALYSIS

Uncertainty is introduced to an exposure pathway analysis through a number of sources. Uncertainty can occur in the measurement of contaminant concentrations in site media and in toxicity values (reference doses and cancer slope factors) used for evaluating the health risks.

As noted in the analytical summary data in the RI, a number of compound values have been qualified by the data validator, indicating uncertainty in the data as to the contaminant concentrations present in the sample. The uncertainty associated with the data therefore results in uncertainty in the chemical scores obtained in the concentration-toxicity screening of the COCs.

The slope factors developed by EPA are generally conservative and are intended to represent an upper-bound limit of the probability of a cancer response. Thus, the actual risk of cancer due to exposure to a contaminant is likely to be lower than the risk calculated using the EPA value. The reference doses are also conservative, and they are generally considered to have an uncertainty of an order of magnitude or more. Consequently, the chemical scores calculated for the COCs during the concentration-toxicity screening (using published reference doses for noncarcinogenic effects and slope factors for carcinogenic effects) may differ from true values.

8.6 CONCLUSIONS

A focused, qualitative health exposure pathway analysis was conducted for the NCIA off-site groundwater contamination to determine COCs and identify potential exposure routes. COCs were selected by reviewing the groundwater analytical data obtained during RI sampling events and determining the frequencies of detection and ranges of detected concentrations of the compounds. A concentration-toxicity screening was then performed to identify those contaminants most likely to contribute significantly to human health risk downgradient of the NCIA. Seven COCs (PCE, TCE, 1,1-DCA, 1,1-DCE, 1,2-DCA, 1,2-DCE, and vinyl chloride) were identified in the off-site groundwater.

No current or future exposure pathways associated with ingestion, inhalation, or dermal contact with potable (tap) water were identified for any population as institutional treatment controls remove the COCs prior to the distribution of the groundwater to the municipal water system. These controls are presently implemented by the Bowling

Green Water District and are anticipated to continue into the future. Potential short-term exposures to contaminated groundwater by remedial workers were identified to exist in the future land use scenario. In addition, short-term inhalation exposures to contamination by individuals that live, work, or visit the area may exist in the future (i.e., via off-gas from a groundwater remediation system). However, these two short-term future pathways can be eliminated with engineering controls, personal protective equipment, and appropriate site health and safety monitoring.

CHAPTER 9

OBJECTIVES OF THE FEASIBILITY STUDY

9.1 INTRODUCTION

The feasibility study (FS) portion of this RI/FS report is presented in Chapters 9 through 12. The primary objective of the FS is to ensure that appropriate remedial alternatives are developed and evaluated such that relevant information concerning remedial action can be presented to a decision-maker (i.e., NYSDEC) and an appropriate remedy selected.

This FS presents remedial alternatives for the impacted off-site groundwater at the NCIA site. In terms of the FS, the NCIA "site" is defined as the properties bound by the Long Island Railroad to the north, Old Country Road to the south, Grand Boulevard and Grand Street to the west, and Frost Street to the east. Groundwater contamination from the NCIA extends south and southwest in the direction of groundwater flow, as shown in Figure 9-1. This FS addresses the off-site groundwater, or the portions of the contaminant plumes south of Old Country Road and Grand Boulevard (see Figures 9-2 through 9-5).

As shown in Figures 9-2 through 9-5, three distinct contaminant plumes originated within the NCIA and have impacted the groundwater to greater than 125 ft bgs (Appendix G also includes a complete set of groundwater contaminant plume maps). The extents of these plumes at depth intervals are depicted in Figures 9-2 (0 - 64 ft bgs), 9-3 (65 – 99 ft bgs), 9-4 (100 – 124 ft bgs), and 9-5 (125 – 200 ft bgs). These plumes have been designated as the “western”, “central”, and “eastern” plumes to ease their identification in the RI/FS, as shown on Figure 9-2.

To date, FS reports have been prepared for NYSDEC that address some of the individual sites within the NCIA. The execution of an active remedial alternative (i.e., one that makes use of a treatment technology) at an individual site will impact the size, shape, and contaminant concentration of the overall groundwater plume. For instance, if a source control and/or groundwater response remedy were implemented at the Frost Street sites, the “eastern” on-site contaminant plume would be expected to shrink or reduce in size with time, and its VOC concentration would decrease although the off-site contaminant plume may not initially change.

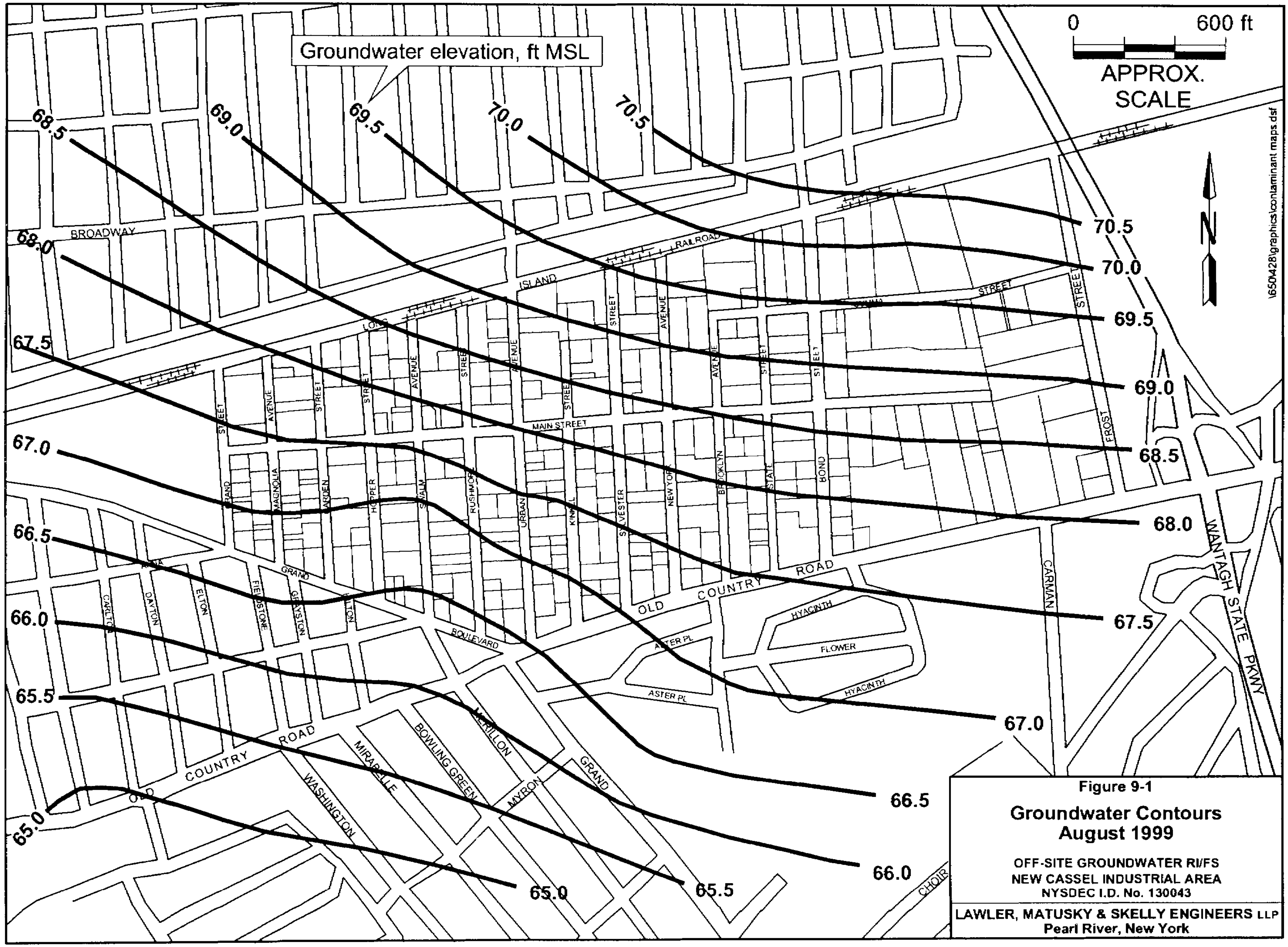


Figure 9-1

Groundwater Contours
August 1999

OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
NYSDEC I.D. No. 130043

LAWLER, MATUSKY & SKELLY ENGINEERS LLP
Pearl River, New York

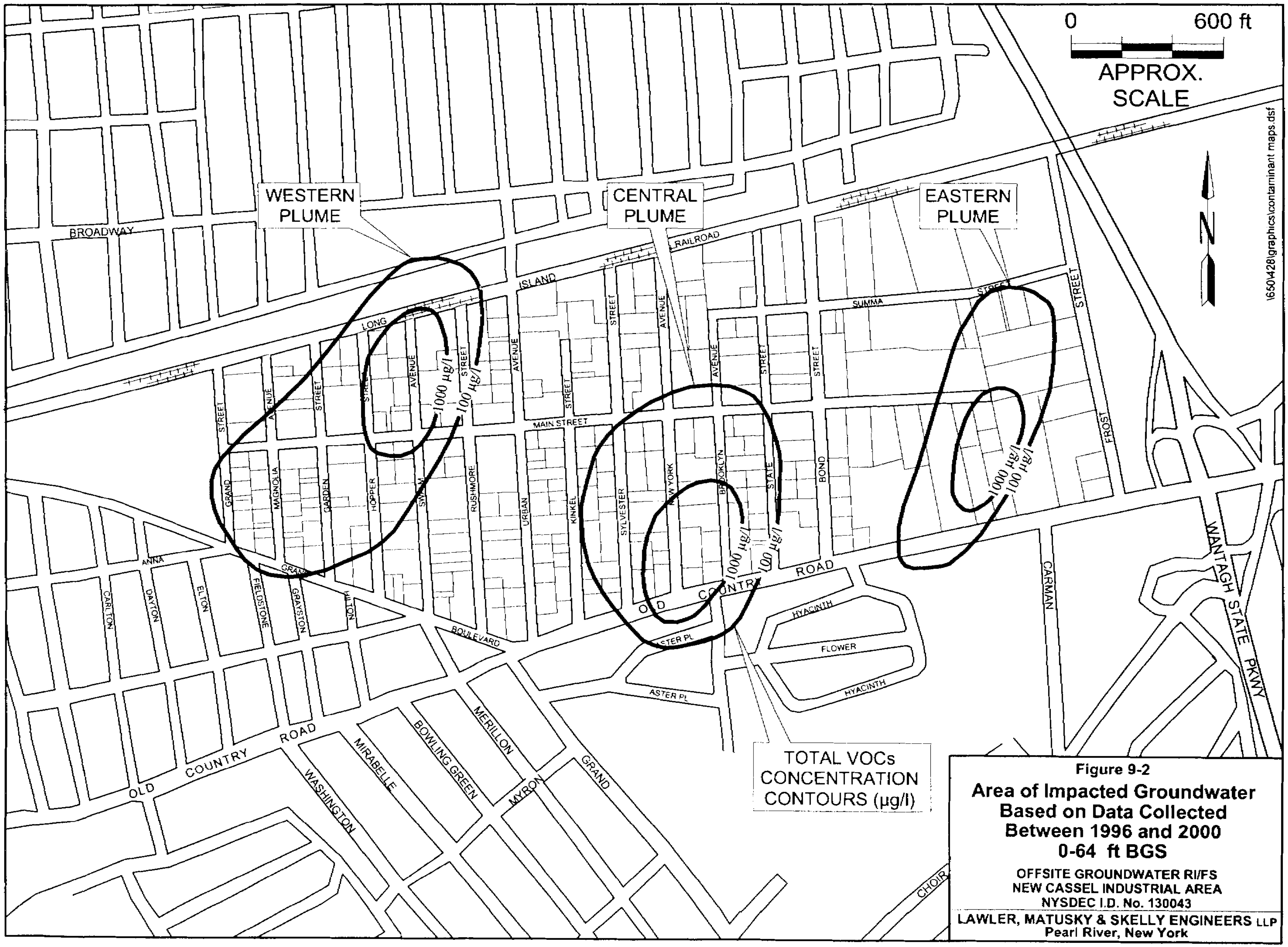


Figure 9-2

Area of Impacted Groundwater Based on Data Collected Between 1996 and 2000 0-64 ft BGS

OFFSITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
NYSDEC I.D. No. 130043

LAWLER, MATUSKY & SKELLY ENGINEERS LLP
Pearl River, New York

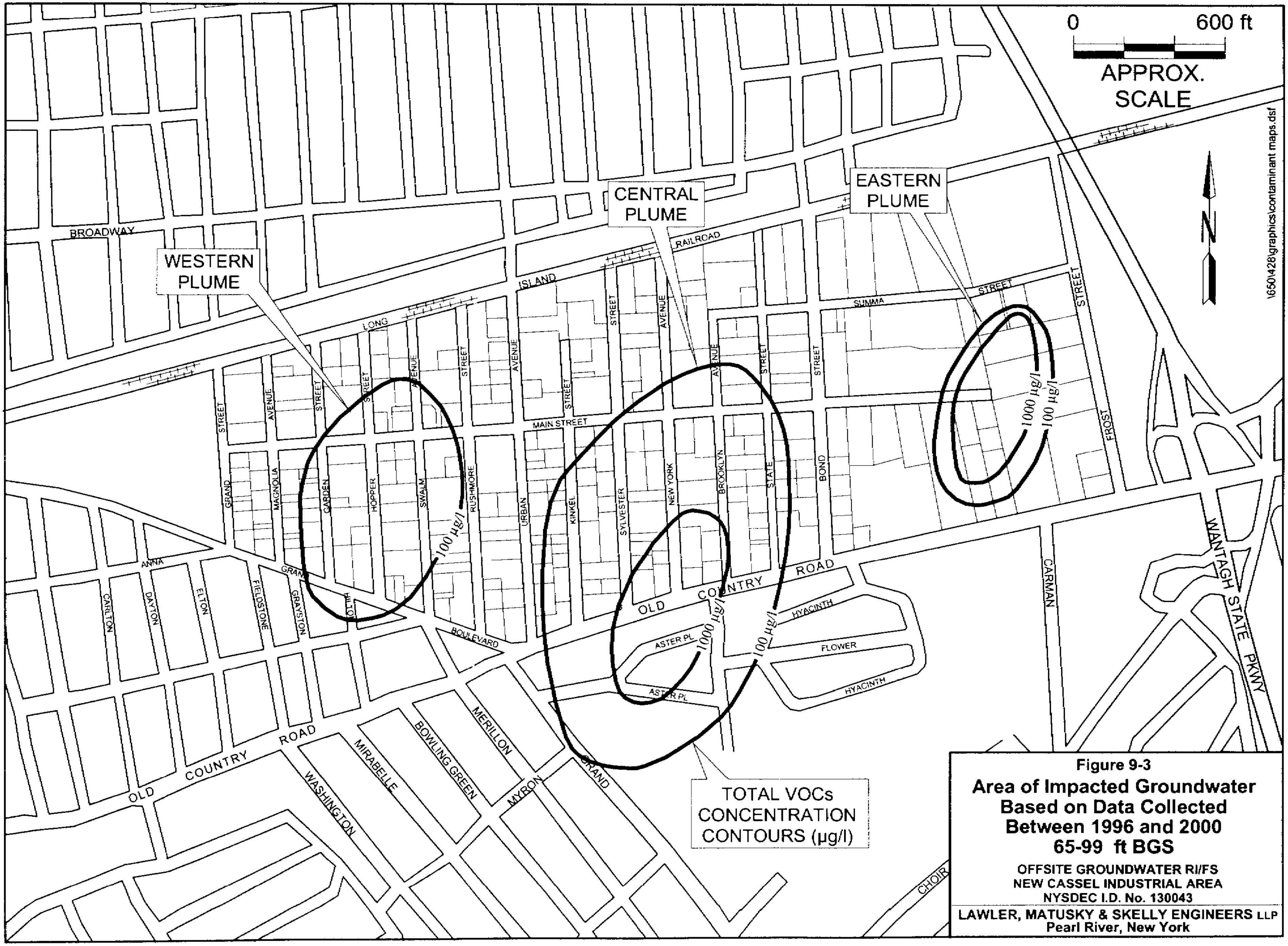


Figure 9-3
Area of Impacted Groundwater Based on Data Collected Between 1996 and 2000 65-99 ft BGS

OFFSITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
NYSDEC I.D. No. 130043

LAWLER, MATUSKY & SKELLY ENGINEERS LLP
Pearl River, New York

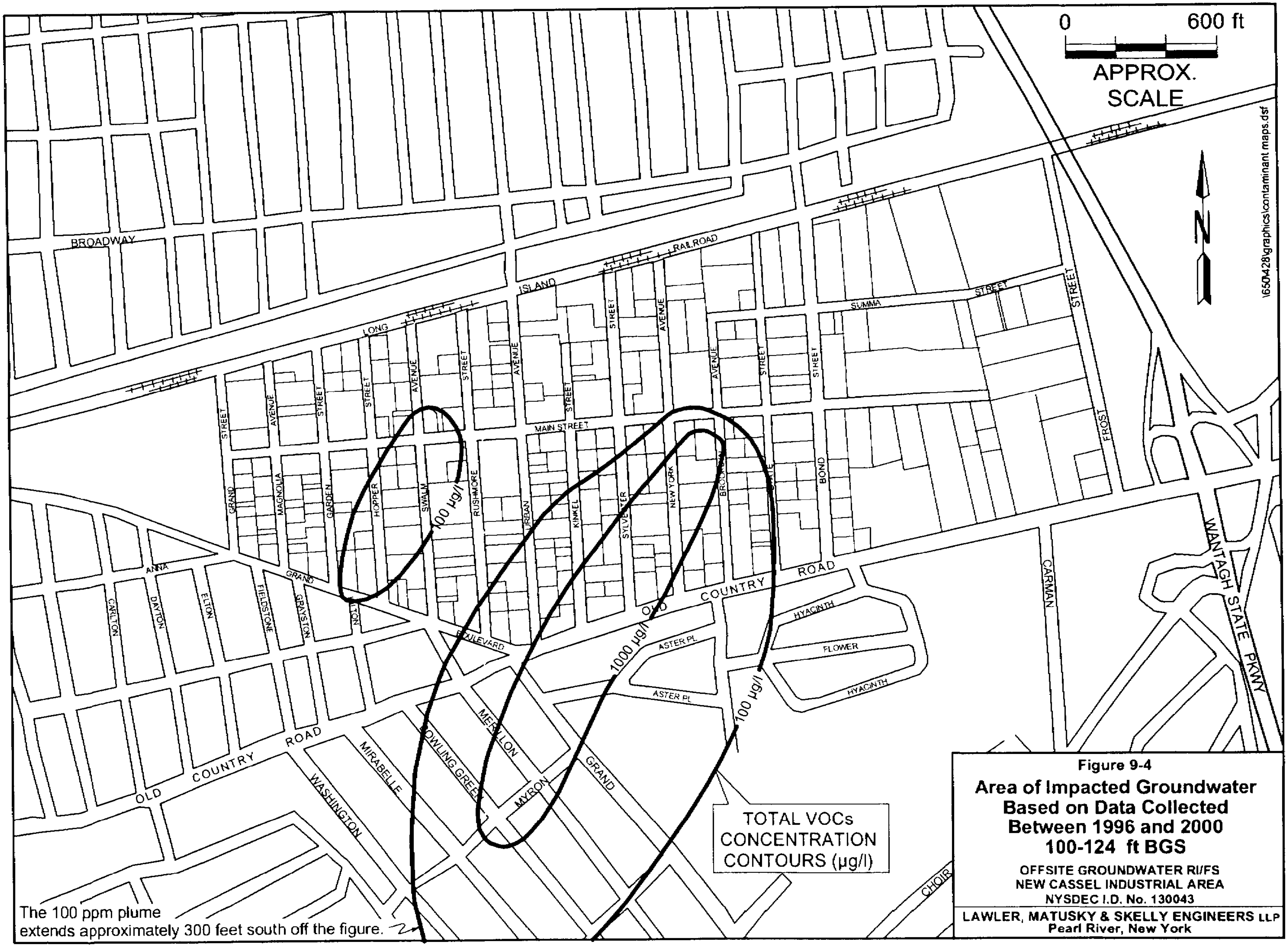


Figure 9-4
Area of Impacted Groundwater Based on Data Collected Between 1996 and 2000 100-124 ft BGS

OFFSITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
NYSDEC I.D. No. 130043

LAWLER, MATUSKY & SKELLY ENGINEERS LLP
Pearl River, New York

Figure 9-5

Area of Impacted Groundwater Based on Data Collected Between 1996 and 2000 125-200 ft BGS

OFFSITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
NYSDEC I.D. No. 130043

LAWLER, MATUSKY & SKELLY ENGINEERS LLP
Pearl River, New York

RI/FSs have been completed at many of the sites in the NCIA, and active groundwater remedial systems are in-place or planned at several sites. It is also likely that additional on-site groundwater remedial systems will be implemented as RI/FSs are completed at other sites. Descriptions of active and proposed remedial activities for sites within the NCIA are provided in Chapter 11.

It is assumed that these on-site remediations will, when implemented, effectively "cut-off" the source of the contaminant plumes and prevent the further release of contaminants off-site. Without a contaminant source, the off-site plumes should with time gradually decrease. However, since no modeling of groundwater contaminant transport was conducted on the NCIA plumes, it is unknown how long it will take for the off-site plumes to be remediated. Therefore, this FS developed remedial alternatives to address the off-site plumes as they exist in the recent studies (1999-2000), assuming no upgradient continuing sources. Conceptual designs of remediation systems are presented in Chapter 11.

Although it was assumed that active measures would be taken at each of the sites within the NCIA, as warranted, to reduce the impact presented by the source areas, realistically all of these on-site remediations cannot be implemented immediately. Therefore, the off-site plumes will continue to change, possibly increasing or decreasing in size and concentrations, from the plumes derived from data from recent studies (1999 – 2000). This FS only address the existing off-site plumes. If the plumes have changed with time and remediations, the selected off-site remedies may be altered at the design phase as necessary to reflect the new sizes or concentrations of the plumes. Records of Decision (RODs) and proposed remedial action plans (PRAPs) that are expected in the next twelve months are summarized in Chapter 11.

9.2 OBJECTIVES OF THE FEASIBILITY STUDY

The FS process (1) identifies remedial action objectives, (2) identifies potential treatment and containment technologies that will satisfy these objectives, (3) screens the technologies based on their effectiveness, implementability, and cost, and (4) assembles technologies and their associated containment or disposal requirements into alternatives for the contaminated media at the site. Remedial alternatives are developed and evaluated with the first seven criteria specified by the National Oil and Hazardous Substances Contingency Plan (NCP) and New York State hazardous waste regulations (6 NYCRR Part 375). These evaluation criteria are (1) protection of human health and the environment, (2) compliance with SCGs, (3) reduction of toxicity, mobility, and volume, (4) short-term effectiveness, (5) long-term effectiveness and permanence, (6) implementability, and (7) cost. The process of alternative development, screening, and evaluation is done in context with remedial action objectives developed for the site and the quantities of contaminated materials present. The eighth criterion, community and state acceptance, is also to be considered in evaluating the remedial alternatives. Community acceptance cannot be assessed until public comments have been received on the RI/FS report and PRAP. The ROD for the off-site groundwater will address community comments.

This chapter presents the remedial action objectives applied to the NCIA off-site groundwater.

9.3 REMEDIAL ACTION OBJECTIVES

Remedial action objectives are developed for a site to determine the levels to which contaminant concentrations must be reduced to protect human health and the environment. The remedial goals should establish cleanup levels for carcinogens that provide protection within the risk range of 10^{-4} to 10^{-6}, in accordance with the NCP requirements developed by the EPA (40 CFR Section 300.430). An acceptable risk of 10^{-6} has been established for this project. Remedial action objectives are also based on reference doses for compounds, i.e., estimates of the daily chemical exposure doses to which individuals can be exposed without an appreciable risk of noncarcinogenic or systemic health effects over a lifetime of exposure (EPA 1993). To evaluate possible risk from exposure to noncarcinogenic contaminants, a hazard quotient (HQ) is calculated by dividing the exposure dose by the reference dose (RfD):

$$HQ = \frac{\text{Exposure Dose}}{\text{RfD}}$$

If the HQ is less than 1, the contaminant is considered unlikely to pose a health hazard to individuals exposed under the given scenario (EPA 1989). This acceptable risk for noncarcinogens (i.e., HQ less than 1) has also been established for this project.

A human health exposure pathway analysis was prepared for the NCIA off-site groundwater (Chapter 8). A pathway analysis, unlike a risk assessment, determines the significant exposure routes and receptors, but does not calculate the chronic daily intake for the COCs or the final carcinogenic and non-carcinogenic risks. Based on this analysis and a review of the applicable standards, criteria, and guidance (Chapter 7), remedial action objectives were established for contaminants in groundwater.

The remedial action objectives developed for the NCIA off-site groundwater serve to:

- Prevent human exposure (inhalation, ingestion, and dermal contact) to the contaminants in the groundwater plumes, which are contaminated with unacceptable levels of the COCs.

- Prevent further migration of contaminants in groundwater.

For the off-site groundwater, a remedial action objective that was established achieves NYSDEC's Class GA groundwater standards (NYSDEC 1998). Achievement of these objectives is believed to be protective of human health and the environment. Although soil above the water table is not an environmental medium that is contaminated in the off-site area, some response technologies may volatize contaminants from the groundwater to soil phase. Thus, the NYS recommended soil cleanup objectives listed in NYSDEC's TAGM #4046 (NYSDEC 1994) will be used as a guide in determining acceptable levels of residual contaminants in soils following a groundwater remedial action.

The data from the RI demonstrated that the off-site groundwater is contaminated with VOCs. More specifically, varying concentrations of PCE, TCE, 1,1-DCE, 1,2-DCE, 1,1-DCA, 1,2-DCA, and vinyl chloride have been identified in shallow (0 - 64 ft bgs), intermediate (65 - 124 ft bgs), and deep (125 - 200 ft bgs) groundwater.

As stated, a remedial action objective is to achieve NYSDEC's Class GA groundwater standards (NYSDEC 1998) for the groundwater medium. Table 9-1 summarizes these numerical standards as they pertain to the off-site groundwater COCs.

TABLE 9-1

CLEANUP OBJECTIVES FOR GROUNDWATER

New Cassel Industrial Area Off-site Groundwater

Contaminant	Class GA Groundwater Standard [1] [ug/l]
Tetrachloroethene	5 *
Trichloroethylene	5 *
1,2-Dichloroethene (total)	5 *
1,1-Dichloroethene	5 *
1,1-Dichloroethane	5 *
1,2-Dichloroethane	0.6
Vinyl chloride	2

1 - NYSDEC Division of Water Technical and Operational Guidance Series (1.1.1), June 1998.
* - Principal organic contaminant standard applies.
MDL - Method detection limit.
SB - Site background.

The above remedial action objectives were used to estimate the quantities of contaminated off-site groundwater present. The estimated quantity of contaminated media is used as a tool for evaluating potential remedial alternatives, including the alternative's cost-effectiveness. Appendix I provides a summary of the estimated quantity of contaminated off-site groundwater of concern, by plume.

CHAPTER 10

IDENTIFICATION AND SCREENING OF TECHNOLOGIES

10.1 INTRODUCTION

The first step in developing a range of alternatives to achieve the remedial action objectives for the NCIA off-site groundwater is to identify potentially applicable remedial technologies. An initial screening is performed in which the applicability of the identified technologies is evaluated in terms of site conditions, contaminants, and contaminated media characteristics. The most promising technologies are combined into site-wide remedial alternatives (Chapter 11), which are then included in the detailed analysis of alternatives section (Chapter 12) of this report.

10.2 GENERAL RESPONSE ACTIONS

The remedial technologies identified for potential application to the "off-site groundwater," as defined in Chapter 9, are evaluated in this chapter. The focus of the remedial responses will be on groundwater restoration because no contaminated soils were identified at locations downgradient of the NCIA. Some groundwater remedial technologies (e.g., air sparging) transfer contaminants from the saturated to the unsaturated zone in order to remove them from the environment. When discussing these technologies, an appropriate soil remediation technology will be discussed that reduces contaminant concentrations in the unsaturated zone.

Some groundwater remedial technologies generate air emissions containing hazardous constituents. If these emissions contain levels of contaminants that exceed regulatory levels, a control technology would be necessary to reduce contaminant concentrations before the emission is released to the atmosphere. Thus, air emission control technologies are evaluated in this FS to the extent they would be needed to implement the groundwater remedy.

The technologies introduced in this chapter are grouped by impacted media and general response actions. Remedial technologies are separated into two categories: (1) "groundwater responses" represent potentially applicable technologies for remediating off-site groundwater and (2) "air emission controls" represent potentially applicable technologies for controlling contaminants from being emitted to the atmosphere. General response actions place the technologies into categories that represent a particular approach to achieving the remedial action objectives. For instance, for groundwater the general response actions include no further action, institutional measures, containment, collection, in-situ treatment, ex-situ treatment, and disposal.

General response categories are further defined by technology types and process options. Technology types are general categories of technologies (e.g., chemical treatment), while process options are specific processes within each technology type (e.g., chemical treatment via oxidation). This review is not an exhaustive list of all available remediation technologies, but summarizes potentially applicable technologies considered for the NCIA off-site groundwater.

10.3 REMEDIAL TECHNOLOGY SCREENING PROCESS

Tables 10-1 and 10-2 list the groundwater response and air emissions control technologies, respectively, identified for potential utilization for the off-site groundwater. The technologies have been grouped according to the medium they address and by general response action. The initial screening was based on the criteria of effectiveness for treating the contaminated media present at the site, implementability given site-specific constraints, and relative cost. COCs retained for the groundwater medium include PCE, TCE, 1,1-DCE, 1,2-DCE, 1,1-DCA, 1,2-DCA, and vinyl chloride. Groundwater treatment technologies were screened based on their effectiveness in reducing the volume and toxicity of dissolved VOCs. If a given technology is only effective to a certain depth below the surface, it may be applicable for remediating the shallow and/or intermediate aquifer zones but not for remediating the deep aquifer zone. Technologies that have limited effectiveness in intermediate or deeper aquifer zones will be noted.

In Tables 10-1 and 10-2, the technologies that are appropriate for treating the medium-specific contaminants were designated as "Yes" for their applicability to the off-site groundwater. A technology that has a site-specific constraint that would prohibit implementation was screened out of the analysis (i.e., designated as "No"). Some

SUMMARY OF REMEDIAL TECHNOLOGIES FOR GROUNDWATER RESPONSE

New Cassel Industrial Area Off-site Groundwater

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE / PROCESS OPTION	APPLICABILITY TO SITE	SCREENING COMMENTS
No Action	None	Yes	Required by the NCP.
Institutional Measures	A. Development Restrictions	Yes	May be used to prevent human contact with contaminants; will not prevent continued migration of contaminants in the groundwater.
	B. Groundwater Use Restrictions	Yes	Effective in preventing use of contaminated groundwater for potable or process source water.
Containment	A. Capping or surface sealing	No	Installation of a surface cap would not be feasible in this developed area as it would disturb too many properties and meet with strong public opposition. Current land use prohibits the installation of a surface cap.
	B. Barriers	Maybe	Must be tied into a low permeable formation, which does not exist in the off-site area. Difficult to implement at depths of greater than 100 ft below grade. Impractical to implement for deep off-site groundwater contamination (but may be used to contain shallow groundwater during remediation of deeper groundwater).
Collection	A. Groundwater pumping	Yes	Used in conjunction with other remedial actions to extract contaminated groundwater for treatment and disposal. It may also be used to lower the groundwater table (to prevent migration of contaminants), and/or reverse the direction of groundwater flow.
	1. Function		
	a. Extraction	Yes	Effective groundwater and contaminant plume control mechanism. This technology is dependent on aquifer characteristics and plume dimensions. Moderate aquifer transmissivities are desirable.

SUMMARY OF REMEDIAL TECHNOLOGIES FOR GROUNDWATER RESPONSE

New Cassel Industrial Area Off-site Groundwater

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE / PROCESS OPTION	APPLICABILITY TO SITE	SCREENING COMMENTS
Collection (Continued)	2. System Options		
	a. Well points or shallow wells	No	May be used to extract groundwater contamination, but to depths of only about 100 ft bgs. Injection of nutrients/chemicals will likely meet opposition from local agencies and public.
	b. Deep wells	Yes	May be used to extract groundwater to the surface.
	c. Pulsed pumping	Maybe	Innovative technology that encourages diffusion of contaminants from stagnation zones into capture zones while reducing the volume of recovered groundwater. Additional evaluation warranted.
	B. Subsurface collection system	No	Impractical because groundwater is encountered at depths over 50 ft below grade.
In-Situ Treatment	A. Biological	No	A sufficient microbial population is not believed to exist because there are not enough nutrients to sustain bacteria. Addition of chemicals to subsurface may meet with local opposition.
	B. Thermal	No	Energy and cost prohibitive.
	1. Hot water or steam heating enhancement	No	Enhancement technique for vaporization of organic compounds.
	C. Physical/chemical	Yes	Potentially effective in reducing VOC concentrations.
	1. Passive treatment walls	No	Innovative technology for the removal of contaminants via subsurface permeable walls. Saturation of bed materials, plugging with precipitates, and short life of treatment materials make technology suitable primarily for temporary remediation. A low permeability layer to tie in the treatment wall does not exist at a shallow enough depth to make this technology feasible.
	2. Funnel and gate systems	No	Combination of barriers and passive treatment walls. Similar limitations to passive treatment walls.
	3. Bioslurping	No	May not be effective in treating contaminants associated with site.
	4. Hydraulic or pneumatic fracturing	No	Used to increase the permeability of low permeability formations, such as clays, tills, and bedrock, for subsequent in-situ treatment or groundwater extraction, especially for volatile organic contamination. Not applicable to existing site conditions.

SUMMARY OF REMEDIAL TECHNOLOGIES FOR GROUNDWATER RESPONSE

New Cassel Industrial Area Off-site Groundwater

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE / PROCESS OPTION	APPLICABILITY TO SITE	SCREENING COMMENTS
In-Situ Treatment (Continued)	5. Air sparging/SVE	No	Would not be effective in removing contaminants from deeper depths due to site specific geological constraints and the weight of the water column.
	6. Surfactants	No	Enhancement technology for increasing mobility and solubility of organic contaminants to improve pump and treat performance. Injection of materials to the subsurface may meet with local opposition.
	7. Cosolvents	No	Enhancement technology for increasing mobility and solubility of organic contaminants to improve pump and treat performance. Injections of chemicals to the subsurface may meet with local opposition.
	8. Electrokinetic remediation	No	Innovative technology that removes inorganics and some organics through electro-osmosis and ion migration. Application has not been demonstrated extensively; significant bench- and pilot-scale tests would be required. Has been applied mostly for metals.
	9. Dual phase extraction	No	Soil contamination is not a primary concern in the off-site areas making this technology unnecessary.
	10. In-well vapor stripping	Yes	Groundwater extraction costs and permitting issues are reduced. Groundwater is treated in well, not ex-situ. Effective also at deeper depths.
	11. Monitored natural attenuation	Yes	Natural attenuation will reduce contaminant concentrations over time and monitoring will track the fate and transport of contaminants.

SUMMARY OF REMEDIAL TECHNOLOGIES FOR GROUNDWATER RESPONSE

New Cassel Industrial Area Off-site Groundwater

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE / PROCESS OPTION	APPLICABILITY TO SITE	SCREENING COMMENTS
Ex-Situ Treatment	A. Biological	No	Requires more operator attention than other similarly effective treatment technologies. Possibility of fouling.
	B. Thermal	No	Energy and cost intensive; not usually effective for liquid contamination with parts per million concentrations. Administrative difficulties may be met.
	C. Physical	Yes	May be used in conjunction with other processes, as determined by waste characterization and treatability studies.
	1. Flow equalization	Yes	Mixing wastes of different concentrations; effective when combined with other treatment technologies.
	2. Sedimentation	Yes	Effective on particulate-phase contaminants only, such as suspended iron.
	3. Carbon adsorption	Yes	Applicable for effluent polishing. Effective in removing organics (through adsorption). Presumptive treatment technology for treatment of dissolved organic contaminants at CERCLA sites.
	4. Ion exchange	No	Generally effective for removal of inorganic contaminants only.
	5. Reverse osmosis	No	Expensive process in comparison with other treatment technologies. Membrane subject to chemical attack, fouling, and plugging.
	6. Air stripping	Yes	Effective for removal of volatile organics and is commonly applied at hazardous waste sites. Presumptive treatment technology for treatment of dissolved organic contaminants at CERCLA sites.
	7. Ultrafiltration	No	Not necessarily effective for the removal of dissolved parameters. Other inorganics or organics present as suspended or colloidal solids may be removed. Generally not as cost-effective in treatment train as other methods.
	8. Synthetic sorptive resins	No	Effective, but is more suitable for thermally unstable compounds (i.e., explosives).
	9. X-ray	No	Emerging technology breaks down organic contaminants to nontoxic compounds. Commercial demonstration of this technology has not been achieved.

SUMMARY OF REMEDIAL TECHNOLOGIES FOR GROUNDWATER RESPONSE

New Cassel Industrial Area Off-site Groundwater

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE / PROCESS OPTION	APPLICABILITY TO SITE	SCREENING COMMENTS
Ex-Situ Treatment (Continued)	D. Chemical	Yes	May be used in conjunction with other processes, as determined by waste characterization and treatability studies.
	1. Precipitation	Yes	Not effective for removal of organics, but may be needed to pretreat water prior to VOC treatment to remove iron and manganese.
	2. Flocculation/coagulation	Yes	May be needed to pretreat water prior to VOC treatment to remove iron and manganese.
	a. Chemical additives	Yes	Not effective for removal of organics, but may be needed to pretreat water prior to VOC treatment to remove iron and manganese.
	b. Alternating current electrocoagulation	No	Not a proven technology used at hazardous waste sites.
	3. Oxidation	No	May effectively remove halogenated volatiles when combined with other processes. Incomplete oxidation may result in the presence of more toxic constituents (e.g., vinyl chloride). Re-injection to subsurface may not be allowed.
	a. Hydrogen peroxide oxidation	No	Effective for the removal of organics. Re-injection may not be allowed.
	b. Chlorine dioxide oxidation	No	Treats only cyanide; does not remove organics.
	c. Catalytic oxidation	No	May be applicable to removal of organics. Re-injection may not be allowed.
	4. Reduction (sulfur dioxide, sodium bisulfite, sodium metabisulfite, or sodium hydrosulfite)	No	May be effective for removal of halogenated volatiles from wastewaters when combined with other processes. Incomplete oxidation may result in presence of more toxic constituents (e.g., vinyl chloride). Re-injection not allowed.
	5. Neutralization	No	Not effective for removing contaminants but may be necessary as pretreatment for other processes.
	6. Chlorination	No	Treats only cyanide, not effective for organics. May be needed to control bacterial clogging of certain treatment/re-injection components.
	7. UV oxidation	Yes	Maybe effective in removing organics when used with another process. CERCLA presumptive remedy treatment technology for remediation dissolved organic contaminants in groundwater.

SUMMARY OF REMEDIAL TECHNOLOGIES FOR GROUNDWATER RESPONSE

New Cassel Industrial Area Off-site Groundwater

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE / PROCESS OPTION	APPLICABILITY TO SITE	SCREENING COMMENTS
Disposal	A. Off-site treatment and/or disposal	No	Volume of groundwater too large to be cost effective to haul and dispose of.
	1. Publicly owned treatment works (POTW)	No	Discussions with local officials indicate that discharge to the POTW is not an option.
	2. TSDF	No	Pumped groundwater may be transported to a permitted TSDF for treatment and disposal. Not cost-effective for large volumes of contaminated water. Treatment residue may need to be treated prior to disposal.
	B. On-site (Local) Discharge	Yes	Treated effluent could be discharged locally.
	1. Deep well injection	No	Deep well injection not practical because of the underlying sole source aquifer.
	2. Discharge via stormwater system (Seepage basin / Dry well injection)	Yes	Treated effluent would require treatment to meet effluent limitations prior to discharge. Local stormwater collection system may be utilized.
	3. Surface impoundment	No	Liquid wastes could not merely be collected and stored; would require treatment. Does not achieve ultimate disposal goals of SARA. Would require large area that is not available at site.

TABLE 10-2

SUMMARY OF REMEDIAL TECHNOLOGIES FOR AIR EMISSIONS CONTROLS

New Cassel Industrial Area Off-site Groundwater

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE / PROCESS OPTION	APPLICABILITY TO SITE	SCREENING COMMENTS
No Action	None	Yes	The emissions generated from a treatment process may be below standards, in which case no air treatment would be required.
Institutional Measures	Placement restrictions	Yes	Can prevent human contact with contaminants through strategic placement of emission sources.
Containment	A. Dust/particulate control measures	No	Not effective in reducing VOC concentrations in air emissions.
	B. Capping or surface sealing	No	Not effective in reducing VOC concentrations in air emissions from a treatment system.
	C. Vertical barriers	No	Not necessary for gas control alone.
Collection	Gas collection	Yes	Vapor phase contaminants from a treatment system will be collected for treatment.
Treatment	A. Carbon adsorption	Yes	For off-gas treatment from other processes only. Not for direct site control. Spent carbon will require off-site regeneration or disposal.
	B. Catalytic Oxidation	Maybe	For off-gas treatment from other processes only. Not for direct site control. Process generates hydrochloric acid, which may require further treatment.
	C. Photocatalytic Oxidation	Yes	For off-gas treatment from other processes only. Not for direct site control. Particulate matter will need to be removed first.
	D. Gas Absorption	Yes	For off-gas treatment from other processes only. Not for direct site control. Process requires packed towers.

technologies were designated as "Maybe" for their applicability because additional site-specific information is necessary to confirm their effectiveness.

A treatment technology is considered "innovative" if it has no or limited full-scale application at Federal hazardous waste sites. A bench- and/or pilot-scale study may be required if an innovative technology is selected. The use of innovative remedial technologies for the NCIA off-site groundwater is limited by the lack of performance data.

10.3.1 **Groundwater Response**

Groundwater response technologies retained in this screening are those that are capable of remediating chlorinated VOCs in the shallow, intermediate, and deep aquifer zones. The shallow zone is defined as the saturated zone between the water table and 64 ft bgs. The intermediate zone is defined as the saturated zone between 65 and 124 ft bgs. The deeper zone is defined as the saturated zone is between 125 and 200 ft bgs.

Measures for controlling the groundwater contaminant plumes are discussed in the following subsections. General response actions for groundwater response include no action, institutional measures, containment, collection, in-situ treatment, on-site treatment, and disposal.

10.3.1.1 ***No Action.*** The no action option is included as a basis for comparison with active groundwater remedial technologies in accordance with the NCP and New York State hazardous waste regulations (6 NYCRR Part 375). With this no action response, contaminants already in the off-site groundwater will continue to migrate in the direction of groundwater flow and will not be controlled or monitored.

10.3.1.2 ***Institutional Measures.*** Applicable institutional measures include development restrictions, which could be applied to the site and downgradient properties. Development restrictions are intended to prevent human contact with contaminants by restricting the use of contaminated groundwater. They can apply to any new construction initiated by the current property owners. Groundwater use restrictions may be applied to prevent future users of the property and downgradient properties from contacting (e.g., via dermal contact or ingestion) contaminated groundwater either as a potable or process water. For this FS, it is assumed that the Bowling Green Water District will, into the future, continue to remove VOC contamination from the groundwater prior to its distribution to the public water supply. Institutional measures are retained for further consideration in the screening process.

10.3.1.3 ***Containment.*** Capping, or surface sealing, will prevent the infiltration of stormwater thereby minimizing the flow of uncontaminated runoff water into the contaminated groundwater. Capping and surface sealing are unrealistic options for the NCIA off-site groundwater as the contaminant plumes are too large in areal extent, encompassing many properties and rights of way. Therefore, the surface capping and sealing options are screened out of the evaluation.

Vertical or horizontal barriers are another type of technology for containing groundwater contaminants and/or preventing contaminant migration. Generally, their applicability is dependent on site-specific geological conditions. A number of different subsurface barrier options are available for groundwater containment, including vertical barrier placement options and construction materials. Barriers may be placed downgradient from the areas of highest concentration to decrease or prevent the migration of contaminated groundwater into uncontaminated areas. They may also be placed upgradient from the area of highest concentration to decrease or prevent the flow of uncontaminated groundwater into the area of the highest contamination. The most effective method of barrier wall placement is to completely surround the contaminant plume, thereby isolating the area of highest concentration. Vertical barriers typically must be keyed into a low permeability formation (e.g., bedrock or clay layer) to prevent groundwater contaminants from escaping the containment. The use of vertical barriers at the off-site area is not recommended due to the impracticality of containing the contaminant plumes and the absence of a low permeability layer at a reasonable depth. However, it may be possible to use vertical barriers for shallow groundwater containment while using another remedy for deeper groundwater. Horizontal barriers may be installed to form a "floor" beneath the area of highest concentration; this technique is referred to as "bottom sealing." However, construction of a horizontal barrier at depths of over 200 ft below grade and over such a wide area is impractical. For these reasons, vertical and horizontal barriers were screened out of the technology evaluation.

10.3.1.4 ***Collection.*** Groundwater pumping is commonly used to extract contaminated groundwater for subsequent treatment and discharge. Pumping may also be used to lower the water table in specific areas to prevent the migration of contaminants into deeper groundwater and to reduce and/or reverse the direction of groundwater flow. Pumping can be instituted alone or in conjunction with other remedial technologies.

Extraction wells are generally used for plume containment and/or groundwater restoration. Application of this technology is dependent on aquifer characteristics and plume dimensions, as well as extracted groundwater treatment and disposal options. The relatively coarse and unconsolidated nature of the soil is such that hollow stemmed auger drilling could be used to install remediation wells.

Another groundwater pumping system option is an innovative technology called pulsed pumping. An enhancement to the pump and treat technology, pulsed pumping involves the use of a noncontinuous pumping regime to encourage the diffusion of contaminants from stagnation and capillary zones into capture zones while reducing the overall volume of recovered groundwater. Additional evaluation of this technology is necessary to determine its suitability for the off-site groundwater.

Wells can be used to inject nutrients, steam, or hot water, if required by a remedial technology. Gravity fed injection wells are used for shallow contamination and are placed close together so that injected reagents can flow vertically instead of laterally. To enable more lateral flow, gravity fed injection wells are used in conjunction with extraction wells. Pressurized injections are used for deeper wells, where the reagents are released at the bottom of the well. Shallow and/or deep wells may be needed to achieve the remedial objectives. However, because the off-site groundwater is classified as a sole source aquifer, it is likely that injection of any nutrient, steam, or hot water into the ground would meet with public or local opposition. These options have been screened from further discussion.

Subsurface collection systems are effective runoff and groundwater collection mechanisms. These systems act to centralize groundwater collection by increasing hydraulic conductivity locally within the saturated zone, but are generally designed to capture groundwater at shallow depths (less than 20 ft below grade). Off-site groundwater is encountered at depths of over 50 ft below grade making subsurface collection systems impractical to implement. These systems have thus been screened from further analysis.

10.3.1.5 ***In-Situ Treatment.*** In-situ treatment technologies include remedial technologies that treat groundwater contaminants in place without bringing them to the surface (via pumping). These techniques are most effective where the contaminant plume is controllable, well-defined, homogeneous, shallow in depth, and relatively small in areal extent. In-situ groundwater treatment technologies that are potentially applicable to the off-site groundwater include biological, thermal, and physical/chemical treatment processes. Also, monitored natural attenuation is introduced in this section as a potentially viable in-situ technology.

Biological Treatment. Enhanced biodegradation exploits the ability of indigenous or introduced bacteria to biodegrade organic compounds under favorable soil conditions by optimizing such factors as oxygen content, pH, and temperature of the groundwater. Some chlorinated compounds (e.g., PCE and TCE) can be biodegraded in the natural environment, but the rate of degradation is dependent on the type of bacteria and the amount of nutrients that are naturally occurring in the local soil and groundwater. Sometimes this in-situ technology requires the injection of nutrients into the subsurface. Nitrate enhancement has proven to be effective only for gasoline constituents to date. Oxygen enhancement with peroxide is often used in conjunction with pump and treat systems to enhance the rate of biodegradation of organic contaminants by naturally occurring microbes. A sufficient microbial population is not believed to exist to conduct enhanced in-situ bioremediation in the off-site area because there are not enough nutrients to sustain bacteria. Also, the addition of chemical constituents to the off-site groundwater may meet with local regulatory and public opposition because of the presence of sole source aquifers that underlie the site. Therefore, enhanced biological treatment is not evaluated further in this analysis.

Thermal Treatment. In-situ thermal treatment processes strive to enhance the recovery of organic contaminants by volatilization. In this process, hot water or steam is forced into the aquifer via injection wells. Vaporized contaminants rise to the unsaturated zone where they can be removed by vacuum extraction and then treated. Thermal treatment techniques can be used to enhance contaminant recovery, but are not recommended as a primary treatment technology. Thermal treatment technologies are not retained for further consideration in the FS because of the considerably greater cost than other treatment methods. There is an extensive amount of energy (i.e., cost) involved with operating these types of systems.

Physical/Chemical Treatment. Physical and chemical in-situ treatment technologies include passive treatment walls, funnel and gate systems, bioslurping, hydraulic or pneumatic fracturing, air sparging, surfactants, cosolvents, electrokinetics, dual phase extraction, and in-well vapor stripping.

Passive treatment walls are an innovative technology for the removal of contaminants from groundwater by subsurface beds (also known as in-situ reactors) filled with adsorptive or reactive media (e.g., ion-exchange resins or limestone) through which contaminated groundwater flows. Within the adsorptive or reactive media, contaminants are captured and degraded over time. Disadvantages of this technology include saturation of bed materials in a relatively short time and plugging of the bed with precipitates. The system also requires consistent control of pH levels to maintain the effectiveness of the treatment wall. As with vertical barriers, passive treatment walls are usually keyed into a low permeability geologic unit (e.g., bedrock or clay) to prevent groundwater contaminants from passing through the wall untreated. At the off-site area, a low permeability geologic unit does not exist at a reasonable depth. Multiple lengthy permeable walls would be necessary to capture the contaminant plumes and their construction would likely span several properties. Due to the extent and depth of the contaminant plumes, construction and installation of the treatment beds would not be feasible.

A funnel and gate system consists of strategically placed in-situ barriers that direct groundwater flow into passive treatment walls, thereby reducing the size of the treatment wall required. The "gate" part of this treatment system (i.e., the passive treatment wall) is subject to the same limitations as described above. The same limitations expressed for passive treatment walls apply to a funnel and gate system; therefore, both were eliminated from the screening process.

Bioslurping uses technology that combines vacuum-enhanced free-product recovery with bioventing of subsurface soils to simultaneously remediate contaminated groundwater and soils. This technology is best suited toward removing light non-aqueous phase liquid (LNAPL). After the free product has been removed, the system can be converted into a conventional bioventing system. Bioslurping has been screened from further discussions because it treats LNAPLs, not the dissolved chlorinated VOCs that are believed to be present in the groundwater.

Hydraulic or pneumatic fracturing is usually applied to low permeability formations, such as clay, till, and bedrock, to increase permeability. These types of formations are not present in the subsurface and the technology is therefore not necessary.

Air sparging is an in-situ groundwater treatment technology applicable for the removal of VOCs and is applied by forcing compressed air into the subsurface to volatilize the contaminants present. The volatilized contaminants rise to the unsaturated zone where they are captured, usually with a soil vapor extraction (SVE) system, and brought to the surface for treatment. Air emissions generated must be monitored and treated appropriately. Based on the geology of the NCIA off-site area and discussions with vendors of the technology, this technology would not be effective at depths exceeding approximately 85 to 100 ft bgs due to the presence of low permeability clay lenses. Also, because the contaminated groundwater is located at extensive depths (200 ft bgs in some areas), the height and weight of the water column would severely limit the effectiveness of this technology. At this depth, the water pressure restricts the creation of air bubbles and would limit contaminant volatilization. Therefore, air sparging/SVE was screened from the analysis.

Controlled injection of surfactants or cosolvents into the groundwater is an innovative technology that is used to mobilize or dissolve contaminants. The surfactant and cosolvent flushing methods can be used in conjunction with a conventional groundwater pump-and-treat system to increase the removal rate of non-aqueous phase liquids (NAPL) and dissolved contaminant by increasing the apparent solubility of the contaminant and reducing interfacial tension between the water and the NAPL. The successful use of surfactants and cosolvents at hazardous waste sites has not been fully demonstrated. Both surfactants and cosolvents were not retained in the screening process because the injection of any constituents to the subsurface would meet with local opposition because of the presence of the sole source aquifer.

Electrokinetic remediation is an innovative treatment technology that separates and extracts heavy metals and some organic contaminants from saturated soils by applying a low intensity direct current on either side of a contaminated area. The electrical current causes electro-osmosis and ion migration, which moves the aqueous phase contaminants in the subsurface from one electrode to the other. The contaminants are then extracted and placed into a recovery system or deposited at the electrode. The electrokinetic remediation process has only had limited commercial application at hazardous waste sites and has mostly been applied to metal contaminants. It is, therefore, screened from the technology review process.

Dual phase extraction is applied by simultaneously extracting contaminated liquid and soil vapor from low permeability or heterogeneous formations by using a series of vacuum extraction wells screened in the unsaturated and saturated zones. As the vacuum is applied to the well, soil vapor is extracted and groundwater is taken along with the extracted vapors. Once above grade, the extracted vapors and groundwater are separated and treated. Dual phase extraction is generally combined with other technologies (e.g., air sparging or bioventing) that are intended to extract VOCs. Because soil contamination is not the primary concern in the off-site areas, dual phase extraction does not provide any added benefits in comparison to simpler technologies. Thus, further evaluation of the dual phase extraction technology is not necessary.

In-well vapor stripping is similar to dual phase extraction in that it treats groundwater without extracting it, but is usually applied to aquifers with moderate to high hydraulic conductivity. The system consists of two major components: 1) pressurized air flow generation and delivery and 2) vacuum extraction. Specialty wells are placed in the areas of the highest VOC contaminant concentrations and/or in areas to contain contaminant migration. The wells are screened both beneath the water table and in the vadose zone. An air line within the well runs from an aboveground supply and extends below the water table. Pressurized air injected below the water table aerates the water within the well, creating a density gradient between the aerated water and the more dense water in the surrounding aquifer. As a result, dense water flows in to the well through the lower well screen and forces the aerated water upward within the well, while becoming aerated itself. The result is a rising column of aerated water within the well, or an air-lift system. As the aerated groundwater column rises within the well, VOC mass transfer occurs from the dissolved phase to the vapor phase. Above the water table, a packer, or deflector plate, is installed at the upper screen to prevent the passage of rising water or bubbles. The rising water column hits the packer, the bubbles burst and the entrained VOC vapor is stripped off laterally through the screen by an upper vacuum casing. As this technology could feasibly be used to treat the off-site groundwater contamination, it has been retained in the screening process.

Of the in situ physical/chemical treatment technologies, in-well air stripping was retained for further evaluation.

Monitored Natural Attenuation. Monitored natural attenuation (MNA) refers to the remediation technology wherein natural processes that reduce contaminant concentrations in the environment are periodically monitored. Natural attenuation is defined as "naturally occurring processes in the environment that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in those media". Natural attenuation is an in-situ process that makes use of natural processes to contain the spread of contamination from chemical spills and reduce the concentration and amount of pollutants at contaminated sites. This means that environmental contaminants are left in place while naturally occurring bacteria and other naturally occurring (chemical, physical) phenomena work at degrading them. These in-situ processes include biodegradation, dispersion, dilution, sorption, volatilization, and/or chemical and biochemical stabilization of contaminants. Natural attenuation has been extensively documented and is increasingly relied upon for the cleanup of soils and groundwater contaminated with fuel hydrocarbons, PAHs, and even chlorinated solvents. The term "monitored natural attenuation," or MNA, refers to the method of monitoring the natural processes that reduce contaminant concentrations over time using sampling, analysis, and modeling (if necessary). The MNA technology has been retained for further evaluation.

10.3.1.6 ***Ex-Situ Treatment.*** A wide variety of technologies are available for the treatment of collected groundwater when it is transferred to the surface, including biological, thermal, physical, and chemical methods. The choice of an appropriate treatment technology is dependent on the nature and concentration of the contaminants present as well as the relative cost and effectiveness of each of the technologies. The presence of more than one type of contaminant in the water stream may require the use of more than one process option in a treatment train. A brief discussion is presented below which describes the available process options for treating collected groundwater via biological, thermal, physical, and chemical technologies.

Biological Treatment. Biological treatment technologies that may be applicable to collected groundwater include treatment in an aerobic and anaerobic reactor. Examples of aerobic reactors include activated sludge, trickling filters, and rotating biological contactors. These technologies are generally applicable for the removal of organic constituents (volatile and semi-volatile compounds) only; the presence of heavy metals may inhibit biological treatment. Activated sludge or trickling filters may be used in conjunction with other treatment processes for the removal of metals. The applicability of these processes to treating collected groundwater needs to be determined in a treatability study. Rotating biological contactors can handle relatively low-strength wastes as compared to the activated sludge and trickling filter processes. Anaerobic filters are generally used for pretreatment of strong wastes. There is the possibility that iron fouling and other undesirable circumstances could occur that would be toxic to the selected bacteria. In addition, biological treatment technologies typically require significantly more operator attention than other types of technologies. For these reasons, biological technologies are being screened out of this evaluation.

Thermal Treatment. Thermal treatment technologies may be effective for removing organic constituents from collected groundwater. Appropriate treatment of air emissions is required to remove any volatilized constituents prior to their release into the atmosphere. Thermal treatment units that have the potential to handle liquids include incinerators (e.g., rotary kiln, fluidized or circulating bed, liquid injection, or infrared), wet air oxidation, and molten salt/plasma arc units. Incineration is generally a costly and energy-intensive process and is not generally effective for liquid streams with parts per million (ppm) contaminant concentrations. Wet-air oxidation and molten glass/plasma arc are both innovative treatment technologies that have not yet been commercially demonstrated at hazardous waste sites, therefore, their reliability and effectiveness are unknown. Administrative difficulties, including air emissions permitting requirements and potential public opposition, may make thermal treatment less likely to be implementable than other comparable treatment technologies. For these reasons, none of these thermal technologies have been retained in the screening process.

Physical Treatment. Numerous physical treatment processes are available for removing organic constituents from collected groundwater. Flow equalization (i.e., mixing of waste streams of different strengths) and sedimentation are commonly applied technologies for reducing contaminant concentrations. Sedimentation is a technology that captures settleable solids from a liquid stream. Sedimentation may be required in the effluent treatment process if precipitated compounds must be removed prior to discharge or to prevent equipment fouling. Sedimentation, in the form of clarification, is retained as a feasible technology option. Activated carbon is a commonly used treatment process for removing organics (through adsorption) and metals (through filtration). Granular activated carbon (GAC) adsorption is a presumptive treatment technology for treatment of dissolved organic contaminants in groundwater of CERCLA sites (EPA 1996).

Activated carbon adsorption is also used as an effluent polishing step. Flow equalization, sedimentation, and activated carbon adsorption have been retained for further evaluation.

Ion exchange can remove dissolved metals and radionuclides from an aqueous solution. Oil, grease, and suspended solids may decrease the efficiency of this technology. This technique has not been retained because it does not effectively treat volatile organics, which are the contaminants of concern at the site. Reverse osmosis is a separation process that forces water through a membrane. The water containing the contaminants that was not able to pass through the membrane is recirculated back to a treatment unit where organic vapors are extracted by a vacuum and then are condensed, thereby minimizing air releases. This wastewater is a small fraction of the original amount of water that needs to be treated, but will require off-site disposal. Because the membrane is susceptible to chemical attack and being clogged, and this technology is expensive relative to other technologies, this process is not given further consideration.

Air stripping is a full-scale technology that removes volatile organics from the groundwater by greatly increasing the surface area of the contaminated water that is exposed to the air. Air stripping is a presumptive treatment technology for treatment of dissolved organic contaminants in groundwater of CERCLA sites (EPA 1996). There are many types of aeration techniques that could be utilized (e.g., packed towers, diffused aeration, tray aeration, and spray aeration). This technology has been retained for further study.

Ultrafiltration is a mechanical separation process based on particle size. The particles are separated by forcing liquid through a semipermeable membrane, whereby only the particles that are smaller than the openings in the membrane can fit through. This technology has not been retained because the contaminants of concern at the site are dissolved in the groundwater; there are no particles to be screened out. Further, it is assumed that any solids control that may be needed in the treatment train of a groundwater remedy will employ less costly methods. Synthetic sorptive resins are similar to the carbon adsorption process and can be designed to achieve higher degrees of selectivity and adsorption capacity for certain compounds than activated carbon. The synthetic resin process is more suitable for thermally unstable compounds, such as explosives, and is therefore screened from further discussions. Using x-rays to break down organic contaminants into nontoxic compounds is an emerging technology that has not been commercially demonstrated and is, therefore, not given further consideration in the screening processing.

Of the physical treatment technologies, flow equalization, sedimentation, carbon adsorption, and air stripping have been retained for further evaluation.

Chemical Treatment. Chemical treatment technologies that may be applicable at these sites in conjunction with other processes include precipitation, flocculation/coagulation, oxidation, reduction, neutralization, chlorination, and ultra-violet (UV) light oxidation/ozonation. Both precipitation and flocculation/coagulation with chemical additions have proved effective for the removal of metals, such as iron and manganese. Precipitation may be needed to pretreat the contaminated groundwater for the removal of iron and manganese prior to VOC removal. Flocculation/coagulation may also be conducted using alternating current electrocoagulation, however this is not a commonly used or proven technology at hazardous waste sites. These processes are effective primarily in the removal of inorganics; treatability studies may need to be conducted to evaluate their effectiveness and optimum operating conditions. Precipitation, flocculation, and coagulation are retained as feasible technologies for the pretreatment of the VOC-contaminated groundwater.

Oxidation and reduction may effectively remove inorganics and VOC when combined with other processes. Incomplete oxidation or reduction may result in the presence of more toxic constituents. Oxidation using hydrogen peroxide is effective for the removal of organics only, while chlorine dioxide oxidation and chlorination are effective primarily for cyanide removal and do not remove metals or organics. Catalytic oxidation uses metal oxides (e.g., nickel oxide, copper oxide, manganese dioxide, and chromium oxide) to oxidize VOCs. Oxidation with hydrogen peroxide and catalytic oxidation and reduction processes have been removed from the screening process in this FS because the groundwater is classified as a sole source aquifer and injection of any chemical into the subsurface, which may occur if treated groundwater is re-injected, is not permitted.

Generally, neutralization is not effective for the removal of contaminants, but may be required to meet discharge limitations or as pretreatment for other processes. Chlorination has been shown to treat cyanides, but is not effective for organic removal. UV oxidation may be effective in removing organics when used in conjunction with other processes. UV oxidation is a presumptive treatment technology for treatment of dissolved organic contaminants in groundwater of CERCLA sites (EPA 1996) and is retained for further evaluation. Due to their limitations, neutralization and chlorination have been eliminated from further discussions.

10.3.1.7 ***Disposal.*** Selection of a disposal or discharge option for collected groundwater depends on the quantity of effluent to be disposed, pretreatment/treatment requirements, and regulatory considerations. Groundwater disposal options were divided into off-site and on-site (i.e., local) options, as discussed below.

Off-site Discharge. Off-site facilities that may potentially accept effluent (untreated groundwater) include the local publicly owned treatment works (POTW) or a treatment, storage, or disposal facility (TSDF). Discussions with local officials indicate that discharges to the sanitary sewer system are not permitted. Therefore, discharge to the POTW was eliminated as an option. Off-site disposal of contaminated groundwater at a TSDF would not be feasible because of the large quantity of groundwater that would be transported to the TSDF.

On-site Discharge. On-site, local discharge options include deep well injection, infiltration through recharge basins and/or dry wells (i.e., utilizing local stormwater collection system), or containment in a surface impoundment. On-site discharge would require treatment to meet applicable NYSDEC groundwater quality standards. Deep well injection is not a practical option because of the presence of the sole source aquifer that lies below the off-site area. Effluent may be transferred to a network of recharge basins or dry wells to allow the water to infiltrate the subsurface, but may be limited by the system's capacity. Appropriate permits or permit equivalents would need to be obtained for this disposal option, and pretreatment standards would have to be achieved. Surface impoundments could not be used due to space limitations and the current use of the properties (i.e., residential and institutional) in the area. Also, surface impoundments do not achieve the ultimate disposal goals of the Superfund Amendment and Reauthorization Act (SARA).

10.3.2 **Air Emissions Controls**

At the NCIA off-site area, the use of air emissions controls should be evaluated and implemented if a groundwater response treatment technology produces air emissions that require control under regulatory requirements. Measures of controlling air emissions are discussed in the following subsections. General response actions for air emissions controls include no action, institutional measures, containment, collection, and treatment.

10.3.2.1 ***No Action.*** The no action option is included as a basis for comparison with active control technologies in accordance with the NCP. In the no action option, air emissions from process equipment are released directly to the atmosphere without being treated. The no action general response has been retained for further comparison.

10.3.2.2 ***Institutional Measures.*** Institutional measures for air emissions controls are intended to reduce the possibility of human contact with contaminants present; however, their effectiveness is limited as they provide a small deterrent to unauthorized access and do not provide protection for workers. Institutional measures, such as distance separation between a treatment system and fence line or greater stack height, are generally used in conjunction with other remedial actions. Institutional measures have been retained in the screening process.

10.3.2.3 ***Containment.*** Containment measures, such as dust/particulate control measures (e.g., water spraying, wind fences or screens, and synthetic dust covers), capping, surface sealing, and vertical barriers would not be effective measures to reduce VOC concentrations in air or control gas migration. Therefore, containment options are not retained for further evaluation.

10.3.2.4 ***Collection.*** Air emissions generated from a groundwater response remedy can be collected in a piping network and transferred to a treatment system and/or to a discharge point. The gas transfer units may include gas extraction wells, collection headers, and vacuum blowers or compressors. Collection methods have been retained for further evaluation.

10.3.2.5 ***Treatment.*** Several technologies exist for treating collected gases or off-gases from other treatment technologies employed including carbon adsorption, catalytic oxidation, photocatalytic oxidation (PCO) treatment, and gas absorption (i.e., wet scrubbing). All four process options are effective in removing gas-phase chlorinated VOC contaminants, but are not designed to remove inorganic compounds, if present. The selection of a particular gas treatment option will depend on the selection of the groundwater response treatment technology, the targeted contaminants to be removed or destroyed, and the relative cost of each technology. For the NCIA off-site groundwater, the air emissions control technology must be capable of reducing low-level VOC concentrations from a remediation unit (e.g., air stripper) to satisfy regulatory requirements.

Carbon adsorption involves a weak bonding of gas molecules, such as vapor phase contaminants, to a solid, such as granular activated carbon (GAC). The forces holding the gas molecules to the solid can be overcome by either the application of heat or the reduction of pressure to regenerate (clean) the carbon. Carbon adsorption is typically conducted in a fixed-bed adsorption system.

Catalytic oxidation is a VOC incineration method that provides thermal destruction of contaminants at relatively low temperatures and has proven to be effective with many dilute VOC-contaminated air emissions. The gases are heated by a burner, then passed through a catalyst bed. The catalyst is usually a noble metal, such as palladium or platinum, deposited on an alumina support in a configuration to give minimum pressure drop. Catalyst activity may be negatively affected by the presence of chlorine or sulfur in treated air emissions. Treatment of chlorinated VOCs will result in the generation of hydrogen chloride, which may require further treatment.

Photocatalytic Oxidation (PCO) is a destructive process for the treatment of gas-phase waste streams. It is best suited for treating waste streams with contaminant concentrations of 1000 ppm of less, and with low to medium flow rates of less than 20,000 cubic feet per minute. This technology is applicable to chlorinated solvents such as TCA, TCE, and PCE. The PCO technology utilizes a titanium compound catalyst, usually titanium dioxide (TiO_2), and near-ultraviolet light to contact a continuously flowing contaminated air stream. PCO causes significant reaction rates to occur at or near room temperature and it is energy efficient. An advantage of the PCO technology is that it does not require reloading with expensive metal, as the catalyst does not foul readily. Unlike catalytic oxidation, hydrogen peroxide is not generated in the process. The process requires both oxygen and water, and particulate matter must be removed first so that it does not foul the catalyst.

Gas absorption refers to the selective transfer of contaminants from a gas to a contacting liquid, such as water. The separation principle involved is the preferential solubility of a gaseous component in the liquid. Gas absorption is usually carried out in packed towers. The gas stream enters the bottom of the column and passes upward through a wetted packed bed. The liquid enters the top of the column and is uniformly distributed over the column packing, which can have any number of commercially available geometric shapes designed to give maximum gas-liquid contact and have a low gas-phase pressure drop.

Carbon adsorption, catalytic oxidation, PCO, and gas absorption are all retained for further analysis.

10.4 EVALUATION OF TECHNOLOGIES AND SELECTION OF REPRESENTATIVE TECHNOLOGIES

Tables 10-3 and 10-4 indicate the technologies that successfully passed the technology screening process (i.e., those technologies listed as "yes" or "maybe" in their applicability to the site) and were considered for further evaluation in this FS. These technologies were considered for inclusion in the remedial alternatives based on their applicability to site conditions and expected effectiveness. Technologies that were not expected to be effective in treating the COCs were screened out, as shown in Tables 10-1 and 10-2. If a technology cannot be implemented due to a particular logistical constraint or if its cost is relatively high compared to other technologies, it was also eliminated from further discussion.

10.4.1 Remaining Groundwater Response Technologies

The groundwater remedial technologies that were retained following the technology screening process are summarized below, separated by general response action (Table 10-3).

10.4.1.1 ***No Action.*** Although no action does not address the contamination present in the off-site groundwater through remedial measures, it has been retained for comparison with other options in accordance with the NCP.

10.4.1.2 ***Institutional Measures.*** In the institutional measures category, development and groundwater use restrictions were retained as feasible institutional controls to minimize human exposure with contaminants remaining in the groundwater. These have been retained because of their low cost, ease of implementation, and effectiveness, assuming that the restrictions are enforced over time. Institutional measures may be

TABLE 10-3

GROUNDWATER RESPONSE TECHNOLOGIES RETAINED

New Cassel Industrial Site Off-site Groundwater

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE / PROCESS OPTION
No Further Action	No further action
Institutional Measures	A. Development Restrictions B. Groundwater Use Restrictions
Containment	None retained
Collection	Groundwater pumping 1. Function Extraction
In situ Treatment	Physical/chemical 1. In-well vapor stripping 2 Monitored natural attenuation
Ex situ Treatment	Physical 1. Carbon adsorption 2. Air stripping
Disposal	On-site Discharge 1. Seepage basin / Wet well infiltration

TABLE 10-4

AIR EMISSIONS CONTROL TECHNOLOGIES RETAINED

New Cassel Industrial Area Off-site Groundwater

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE / PROCESS OPTION
No Action	None
Institutional Measures	Placement restrictions
Containment	None
Collection	Collection of contaminated vapor phase
Treatment	Granular activated carbon

selected as part of a remedial alternative. For this FS, it is assumed that the Bowling Green Water District will, into the future, continue to remove VOC contamination from the groundwater prior to its distribution to the public water supply.

10.4.1.3 ***Containment.*** No containment technologies were retained as groundwater response controls largely because their implementations are impractical.

10.4.1.4 ***Collection.*** Of the groundwater collection technologies, extraction wells have been retained for further discussion. Groundwater pumping via extraction wells has been proven to be an effective contaminant plume control mechanism.

10.4.1.5 ***In-Situ Treatment.*** Only one active in-situ treatment technology was retained: in-well vapor stripping. Other active technologies are not likely to be effective at depths of 100 to 200 ft below grade. In this category, monitored natural attenuation was also retained for further evaluation.

10.4.1.6 ***Ex-Situ Treatment.*** Two physical technologies, carbon adsorption and air stripping, were retained for further evaluation. Flow equalization and sedimentation were retained for possible use in groundwater remedy treatment trains to remove inorganics and organics from liquids prior to VOC treatment or groundwater discharge. No chemical ex-situ treatments were retained for VOC treatment; however, precipitation, flocculation, and coagulation may be needed to pretreat the contaminated groundwater prior to VOC removal unit processes. UV oxidation can be used to reduce VOC levels in the liquid phase, but it is assumed for purposes of this FS that liquid phase VOC treatment will not be the focus of the groundwater remedy.

Carbon adsorption was retained since polishing of effluent water from a treatment system may be required prior to discharge. For these purposes, GAC was determined to be more cost-effective than UV oxidation.

10.4.1.7 ***Disposal.*** No off-site treatment and disposal options were retained. Feasible local discharge options include the use of the existing stormwater collection system (e.g., a retention basin) or seepage basins/wet wells to allow for infiltration. Contaminant concentrations in the effluent would need to satisfy applicable regulatory requirements.

10.4.2 Remaining Air Emissions Control Technologies

Air emissions control technologies that were retained following the screening evaluation are summarized below and listed in Table 10-4. Air emissions controls may be needed to meet state and Federal air discharge requirements if a remediation process generates an air emission.

The no action and institutional measures options were retained in the evaluation for the case where no air emissions controls are required for the selected remediation process. If controls are necessary, options include containment, collection, or treatment. For dust controls resulting from excavation activities, containment technologies (e.g., water spraying, wind fences, and dust covers) were retained for potential use.

Carbon adsorption (GAC) was selected for this FS as the treatment technology to reduce VOC concentrations in an air stream. The selection of this technology for a particular application (i.e., in-well vapor stripping or groundwater extraction/air stripping) was based on anticipated flow rates, contaminant concentrations, and operating periods. GAC was also determined to be cost-effective when compared to the other treatment technologies (catalytic oxidation, photocatalytic oxidation, and gas absorption). As described in Chapter 11, these other treatment technologies may need to be further evaluated for particular groundwater remedies based on pilot tests and system monitoring.

CHAPTER 11

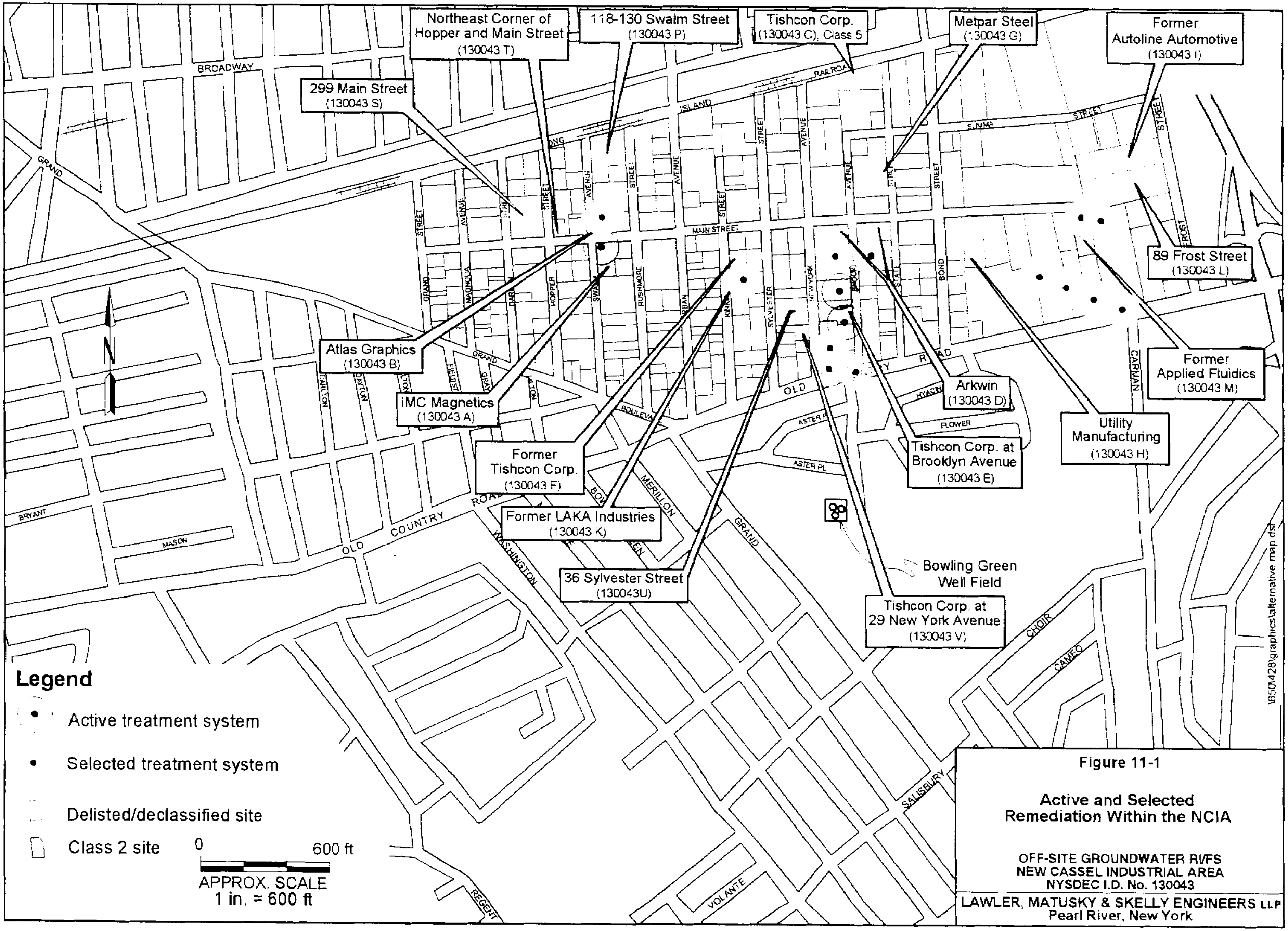
DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

11.1 INTRODUCTION

In accordance with NYSDEC's TAGMs HWR-89-4025, Guidelines for Remedial Investigations/Feasibility Studies (NYSDEC 1989), and HWR-90-4030, Selection of Remedial Actions at Inactive Hazardous Waste Disposal Sites (NYSDEC 1990), preliminary remedial alternatives for a site are developed by combining the remedial technologies that have successfully passed the screening stage into a range of alternatives. The goal of the screening process is to reduce the number of alternatives that will be included for subsequent detailed analysis by identifying those that are most compatible with the conditions of the site.

Chapter 10 identified and screened the available remedial technologies for treating the contaminated NCIA off-site groundwater. Based on the relatively small number of potentially applicable technologies and existing constraints, the development and formal evaluation of a wide range of unlikely preliminary alternatives was unnecessary. Instead, a group of remedial alternatives that appeared most feasible and appropriate for the off-site groundwater contamination was developed for detailed evaluation. This chapter presents these remedial alternatives developed to address the NCIA off-site groundwater contamination, as defined in Chapter 9.

As stated in previous chapters, this FS is based on the presumption that the selected remediation at source sites within the NCIA will be implemented. Further, it is assumed that additional groundwater remedies will be implemented as RI/FSs are completed at other sites within the NCIA. Summaries of active groundwater remediation that is either in-place at or selected for the individual sites within the NCIA are provided below and in Figure 11-1. Currently, there are 13 individual sites within the NCIA that are listed as Class 2 sites on the NYSDEC Registry.



Northeast Corner of
Hopper and Main Street
(130043 T)
118-130 Swalm Street
(130043 P)
Tishcon Corp.
(130043 C), Class 5
Metpar Steel
(130043 G)
Former
Autoline Automotive
(130043 I)
299 Main Street
(130043 S)
89 Frost Street
(130043 L)
Atlas Graphics
(130043 B)
IMC Magnetics
(130043 A)
Former
Tishcon Corp.
(130043 F)
Former LAKA Industries
(130043 K)
36 Sylvester Street
(130043U)
Arkwin
(130043 D)
Tishcon Corp. at
Brooklyn Avenue
(130043 E)
Utility
Manufacturing
(130043 H)
Former
Applied Fluidics
(130043 M)
Bowling Green
Well Field
Tishcon Corp. at
29 New York Avenue
(130043 V)
BROADWAY
GRAND
ISLAND
RAILROAD
MAIN STREET
OLD COUNTRY ROAD
WASHINGTON
MERILLON
CARMAN
FLOWER
ASTER PL
BRYANT
MASON
VOLANTE
REGENT
SALISBURY
CHOIR
CAMEO
Legend
Active treatment system
Selected treatment system
Delisted/declassified site
Class 2 site
0
600 ft
APPROX. SCALE
1 in. = 600 ft
Figure 11-1
Active and Selected
Remediation Within the NCIA
OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
NYSDEC I.D. No. 130043
LAWLER, MATUSKY & SKELLY ENGINEERS LLP
Pearl River, New York
\850428\graphics\alternative map.dsf

11.1.1 **IMC Magnetics (Site No. 1-30-043A)**

Remedial History. This site is located at 570 Main Street within the western groundwater plume area and was listed on the Registry as a Class 2 site in 1995. Further investigations on this site revealed that the soils and groundwater were contaminated with chlorinated VOCs. In October 1997, IMC began to operate a SVE system at the site as an interim remedial measure (IRM) to remediate the on-site soil contamination. SVE was subsequently selected as the final soil remedy. A focused groundwater RI/FS at this site confirmed the presence of an on-site chlorinated VOC groundwater plume. The active groundwater remediation at this site will include in-situ oxidation (hydrogen peroxide injection) to oxidize the contaminants. The ROD for the groundwater remediation was issued by NYSDEC in March 2000.

11.1.2 **Atlas Graphics (Site No. 1-30-043B)**

Remedial History. This site is located at 567 Main Street within the western groundwater plume area and was listed on the Registry as a Class 2 site in 1995. The analytical results for this site indicated that elevated levels of TCE were found on-site in both the soil and groundwater. The ROD for this site, issued in February 2000, selected air sparging/soil vapor extraction (AS/SVE) as the remedy to address the on-site contaminated soils and groundwater. Design and construction of the system is likely to proceed during the later half of 2000.

11.1.3 **Arkwin Industries (Site No. 1-30-043D)**

Remedial History. This site includes a number of individual lots located along Main Street within the central groundwater plume area. Based on the presence of chlorinated VOCs and petroleum hydrocarbons in the soils and groundwater at the site, the Arkwin site was added to the Registry as a Class 2 site in 1995. The contaminated soil was excavated in June 1997 as part of an IRM. A focused RI/FS for the groundwater (O.U. 2) was subsequently conducted. The RI results indicated the presence of several VOCs and their breakdown products above the groundwater standard in both the UGA and the Magothy aquifer. The focused FS evaluated a number of remedial alternatives for the groundwater. Based on the FS, NYSDEC selected AS/SVE as the remedy for the groundwater. The ROD for O.U. 2 was issued in December 1999.

11.1.4 **Tishcon Corporation at Brooklyn Avenue (Site No. 1-30-043E)**

Remedial History. This site is located at 30-36 New York Avenue and 30-33 Brooklyn Avenue within the central groundwater plume area. Based on information obtained from a NCIA-wide PSA, Tishcon was added to the Registry as a Class 2 site in 1995. Sampling results showed high levels of chlorinated VOCs (including 1,1,1-TCA) in the soils and groundwater. An IRM, completed in November 1997, removed the soil contamination in an out-of-service cesspool, a sealed storm drain, and an exterior floor drain. A ROD was issued by NYSDEC in January 1998; the ROD also required the installation of an AS/SVE system to address any remaining on-site soil and groundwater contamination. Construction of the on-site AS/SVE system was completed in December 1999, and system operation began in January 2000. To date the system is performing at or above specifications. A focused off-site groundwater RI/FS was finalized in September 1999. The selected remedy consists of the installation of an AS/SVE system to remove the VOC contamination in the off-site groundwater near Old Country Road. The ROD was issued in March 2000.

11.1.5 **Utility Manufacturing/Wonder King Site (Site No. 1-30-043H)**

Remedial History. The Utility Manufacturing/Wonder King site (Utility site) is located at 700-712 Main Street near the eastern plume area. An NYSDEC monitoring well sampling program and a PSA confirmed that soil and groundwater were contaminated with PCE and other related VOCs above standards and guidelines. Consequently, the NYSDEC listed the Utility site as a Class 2 site in March 1996. A subsequent field investigation was completed in May 1998 and included the collection of soil samples and installation and sampling of monitoring wells. The NYSDEC required Utility to conduct an additional investigation to delineate the on-site groundwater contamination and perform an IRM to remediate the on-site groundwater. To date, no final PRAP or ROD has been prepared for the site.

11.1.6 **Former LAKA Industries, Inc. (Site No. 1-30-043K)**

Remedial History. The former LAKA site is located at 62 Kinkel Street which is within the central groundwater plume area. A focused RI/FS was conducted to define the nature and extent of contamination at the site. The RI (finalized May 1999) confirmed that contamination exists in the vicinity of an on-site cesspool and that an additional source area exists in a catch basin located downgradient of the site. NYSDEC prepared the PRAP in September 1999 and issued the ROD in February 2000. The selected remedy consists of excavation of the abandoned cesspool and removal of the contaminated sediments from the catch basin. On-site groundwater quality will continue to be monitored for two more years to measure improvements after the sources are removed.

11.1.7 **Frost Street sites: Former Autoline Automotive (Site No. 1-30-043I); 89 Frost Street (Site No. 1-30-043L); and Former Applied Fluidics (Site No. 1-30-043M)**

Remedial History. The Frost Street sites include three adjacent sites which are located at 89 Frost, 101 Frost Street, and 770 Main Street. The three sites appear to be the origin of the eastern groundwater plume. Based on the results of a PSA that included the installation of soil and groundwater probes, the NYSDEC designated the sites as Class 2 sites in March 1996.

In 1998, a RI/FS was conducted at the Frost Street sites. The RI report was finalized in August 1999 and the investigation determined that the VOC contaminants of concern were PCE, TCE, and xylene. Based on the FS, NYSDEC prepared the PRAPs in January 2000 that described the recommended remedies for the soils at the three sites. The remedies consist of the excavation and disposal off-site of the surficial soils from hot spots, removal of contaminated soil and sediment from ten on-site dry wells, and treatment of deep soil contamination with a SVE system. The RODs were signed in March 2000.

The groundwater contamination was addressed as a combined operable unit since the contamination emanating from the three Frost Street sites co-mingles, such that the contamination from one site mixes with the contamination from an adjacent site forming a common plume of VOC contamination. Based on the FS, NYSDEC prepared the PRAP that consists of the installation of an AS/SVE system to address VOC contamination in the groundwater source areas and an in-well vapor stripping system to address the deeper contamination including areas along Old Country Road. The ROD was signed in March 2000.

11.1.8 **118-130 Swalm Street Site (Site No. 1-30-043P)**

Remedial History. A PSA conducted in 1995 identified the 118-130 Swalm Street site as a potential ("P") site. Further investigations identified the site as a source for the western plume area, and the site was listed on the Registry as a Class 2 site in 1997. The NYSDEC negotiated a Consent Order with the property owner in October 1998 to conduct an RI/FS and IRM of the site. Field work was completed in January 1999. RI results indicated low levels of VOC contamination in on-site cesspools and that the groundwater contamination had decreased over time. Additional investigative work in the cesspools is currently underway. To date, no PRAP or ROD has been prepared on the site.

11.1.9 **299 Main Street Site (Site No. 1-30-043S)**

Remedial History. Based on several phases of sampling and analysis of the soils and groundwater at this site, the NYSDEC listed the 299 Main Street site on the Registry as a Class 2 site in 1997. A Consent Order was negotiated in May 1999 between NYSDEC and the owner to conduct a focused RI/FS. Field work was completed in October 1999, and a draft focused RI report was submitted which indicated the soils and groundwater at the site were contaminated with chlorinated compounds. Additional characterization work and interim remedial measures are scheduled for the Fall of 2000. To date, no PRAP or ROD has been prepared for the site.

11.1.10 **36 Sylvester Street Site (Site No. 1-30-043U)**

Remedial History. The results of the PSA indicated that past site operations have contaminated the groundwater beneath and downgradient of the site with 1,1,1-TCA. NYSDEC listed the 36 Sylvester Street site as a Class 2 site on the Registry in September 1999. NYSDEC has negotiated a Consent Order with the PRP to conduct a RI/FS in 2000. This site is within the central plume area west of the Tishcon Corporation at Brooklyn Avenue site (Site No.1-30-043E) and north of the Tishcon Corporation site at 29 New York Avenue (Site No. 1-30-043V).

11.1.11 **Tishcon Corporation Site at 29 New York Avenue (Site No. 1-30-043V)**

Remedial History. Based on the results of an initial NCIA-wide PSA, this site was listed on the Registry as a Class 2 site in 1995 as part of the Tishcon Corporation at Brooklyn Avenue site. The 29 New York Avenue site was investigated further as part of another PSA conducted in 1996. A soil/sediment sample from an on-site catch basin had TCA-related compounds above cleanup guidelines; it also exhibited a high concentration of vitamin E. Based on these results, the NYSDEC placed the Tishcon Corporation at 29 New York Avenue site as a separate Class 2 site on the Registry in March 1998. This site is also within the central plume area. A Consent Order was negotiated between NYSDEC and the property owner in March 1999 to conduct an RI/FS and IRM on the site. The RI report was received by NYSDEC in December 1999. A proposal to conduct an IRM has also been received from the property owner's consultant.

11.2 **REGULATORY REQUIREMENTS**

New York State hazardous waste regulations and the NCP include requirements for the development of remedial alternatives to ensure that the alternatives selected will provide decision-makers with an appropriate range of options, as well as sufficient information to compare the alternatives. The range of options depends on the site-specific conditions but, to the extent possible, the development of one or more alternatives in each of the following categories is recommended:

1. The no or minimal action alternative.

2. A range of alternatives that includes treatment to reduce the toxicity, mobility, or volume of contaminants present, including:

    a. An alternative that removes or destroys contaminants to the maximum extent possible and minimizes the need for long-term management of remaining wastes or waste treatment residuals.

b. One or more alternatives that vary in the degree of treatment and long-term management required.

c. An alternative that involves little or no treatment but protects human health and the environment through containment or institutional controls to prevent exposure to hazardous materials.

3. A range of alternatives that achieve the contaminant-specific remedial action levels within different time periods.

4. One or more innovative treatment technologies, if any such technologies appear promising (i.e., comparable or superior performance for lower cost).

The development and selection of a final range of remedial alternatives which addresses the New York State and NCP requirements of feasibility studies are developed in this chapter. Eleven alternatives were developed for detailed evaluation.

11.3 DEVELOPMENT OF REMEDIAL ALTERNATIVES

Table 10-3 in Chapter 10 indicates the groundwater response technologies that successfully passed the screening. These technologies were considered for inclusion in the remedial alternatives based on their applicability to local conditions and expected effectiveness on reducing groundwater contaminant concentrations in a reasonable time frame. Technologies that were retained but not subsequently incorporated into alternatives may be substituted for any technology that proves to be ineffective following a bench or pilot scale study.

Eleven groundwater response alternatives were selected for inclusion in the detailed evaluation of alternatives. The technical elements of each are summarized in Table 11-1. This chapter provides a detailed description of the eleven selected groundwater response alternatives. Chapter 12 presents the evaluation of these alternatives against the criteria of protection of human health and the environment; compliance with state and Federal SCGs; short-term impacts and effectiveness; long-term impacts, effectiveness, and permanence; reduction of toxicity, mobility, or volume; implementability; and cost.

TABLE 11-1

REMEDIAL ALTERNATIVES FOR DETAILED EVALUATION

New Cassel Industrial Area Off-site Groundwater

ALTERNATIVE	GENERAL RESPONSE ACTION/TECHNOLOGY TYPE
ALTERNATIVE 1: No Further Action	• Development and groundwater use restrictions • Operation and maintenance of VOC treatment at Bowling Green Water District
ALTERNATIVE 2: Monitored Natural Attenuation	• Development and groundwater use restrictions • Baseline site characterization • Long-term groundwater monitoring to measure the fate and transport of contaminants • Operation and maintenance of VOC treatment at Bowling Green Water District
ALTERNATIVE 3: Monitoring, Assessment and Contingent Remediation	• Development and groundwater use restrictions • Long-term groundwater monitoring to measure the fate and transport of contaminants • Periodic data reduction and maintenance • Technical data and remedial alternative evaluation after each year • Operation and maintenance of VOC treatment at Bowling Green Water District
ALTERNATIVE 4A: Remediation of Upper Portion of Aquifer (to 125 ft bgs) with In-Well Vapor Stripping / Localized Delivery and Vapor Treatment	• In-well groundwater circulation system addressing contamination in upper portion of aquifer • Localized air delivery systems • Vapor collection at wellheads • Localized vapor treatment systems • Air emissions control (GAC) • System performance monitoring • Operation and maintenance of VOC treatment at Bowling Green Water District
ALTERNATIVE 4B: Remediation of Upper Portion of Aquifer (to 125 ft bgs) with Groundwater Extraction / Centralized Air Stripping and Vapor Treatment / Effluent Re-Injection	• Groundwater extraction wells addressing contamination in upper portion of aquifer • Groundwater transfer to central treatment system • Pretreatment of influent • Air stripping of liquid phase VOCs • Sludge generation and off-site disposal • Central air emissions control (GAC) • Central injection of treated effluent • System performance monitoring • Operation and maintenance of VOC treatment at Bowling Green Water District
ALTERNATIVE 5A: Remediation of Upper and Deep Portions of Aquifer (to 200 ft bgs) with In-Well Vapor Stripping / Localized Delivery and Vapor Treatment	• In-well groundwater circulation system addressing contamination in upper and deep portions of aquifer • Localized air delivery systems • Vapor collection at wellheads • Localized vapor treatment systems • Air emissions control (GAC) • System performance monitoring • Operation and maintenance of VOC treatment at Bowling Green Water District

TABLE 11-1

REMEDIAL ALTERNATIVES FOR DETAILED EVALUATION

New Cassel Industrial Area Off-site Groundwater

ALTERNATIVE	GENERAL RESPONSE ACTION/TECHNOLOGY TYPE
ALTERNATIVE 5B: Remediation of Upper and Deep Portions of Aquifer (to 200 ft bgs) with Groundwater Extraction / Centralized Air Stripping and Vapor Treatment / Effluent Re-Injection	• Groundwater extraction wells addressing contamination in upper and deep portions of aquifer • Groundwater transfer to central treatment system • Pretreatment of influent • Air stripping of liquid phase VOCs • Sludge generation and off-site disposal • Central air emissions control (GAC) • Central injection of treated effluent • System performance monitoring • Operation and maintenance of VOC treatment at Bowling Green Water District
ALTERNATIVE 6A: Full Plume Remediation of Upper Portion of Aquifer (to 125 ft bgs) with In-Well Vapor Stripping / Localized Delivery and Vapor Treatment	• In-well groundwater circulation system addressing contamination in upper portion of aquifer (full plume remediation to 125 ft bgs) • Localized air delivery systems • Vapor collection at wellheads • Localized vapor treatment systems • Air emissions control (GAC) • System performance monitoring • Operation and maintenance of VOC treatment at Bowling Green Water District
ALTERNATIVE 6B: Full Plume Remediation of Upper Portion of Aquifer (to 125 ft bgs) with Groundwater Extraction / Centralized Air Stripping and Vapor Treatment / Effluent Re-Injection	• Groundwater extraction wells addressing contamination in upper portion of aquifer (full plume remediation to 125 ft bgs) • Groundwater transfer to central treatment system • Pretreatment of influent • Air stripping of liquid phase VOCs • Sludge generation and off-site disposal • Central air emissions control (GAC) • Central injection of treated effluent • System performance monitoring • Operation and maintenance of VOC treatment at Bowling Green Water District
ALTERNATIVE 7A: Full Plume Remediation of Upper and Deep Portions of Aquifer (to 200 ft bgs) with In-Well Vapor Stripping / Localized Delivery and Vapor Treatment	• In-well groundwater circulation system addressing contamination in upper and deep portions of aquifer (full plume remediation to 200 ft bgs) • Localized air delivery systems • Vapor collection at wellheads • Localized vapor treatment systems • Air emissions control (GAC) • System performance monitoring • Operation and maintenance of VOC treatment at Bowling Green Water District
ALTERNATIVE 7B: Full Plume Remediation of Upper and Deep Portions of Aquifer (to 200 ft bgs) with Groundwater Extraction / Centralized Air Stripping and Vapor Treatment / Effluent Re-Injection	• Groundwater extraction wells addressing contamination in upper and deep portions of aquifer (full plume remediation to 200 ft bgs) • Groundwater transfer to central treatment system • Pretreatment of influent • Air stripping of liquid phase VOCs • Sludge generation and off-site disposal • Central air emissions control (GAC) • Central injection of treated effluent • System performance monitoring • Operation and maintenance of VOC treatment at Bowling Green Water District

The groundwater response alternatives address the off-site groundwater plumes, as previously defined, downgradient of the NCIA. The remediation systems proposed focus on treating the groundwater from the water table (located approximately 55 ft bgs) to 125 ft bgs (Alternatives 4A, 4B, 6A, and 6B) and to 200 ft bgs (Alternatives 5A, 5B, 7A, and 7B) to reduce elevated VOC concentrations in the upper and deep portions of the aquifer and prevent the plume from spreading to further downgradient locations at significant concentrations. The configurations of the off-site groundwater plumes are shown in Figures 9-2 through 9-5.

11.3.1 **Alternative 1: No Further Action**

Alternative 1 is considered to be the no further action alternative, required by the NCP, because it does not include active treatment of the off-site contaminant plumes. As discussed above, active source removal and groundwater remediation is in-place or planned at 13 source sites within the NCIA. Alternative 1 includes institutional controls in the form of development and groundwater use restrictions. These controls will prohibit the use of groundwater for potable or industrial use. In addition, it is assumed that the Bowling Green Water District will continue to remove VOCs from the groundwater prior to distribution to the water supply system. Groundwater use restrictions will be implemented to prevent development of the underlying groundwater as a potable or a process water source without necessary water quality treatment as determined by NYSDEC. Implementation of development and use restrictions is a method of enforcing groundwater use restrictions.

A 30-yr alternative timeframe has been assumed in order to allow for cost comparisons among the other alternatives. The cost estimate developed for this no further action alternative assumes operation and maintenance, including replacement of equipment as needed, of the VOC treatment processes that are currently in-place at the Bowling Green Water District. The O&M items associated with VOC treatment were developed based on conversations with water district personnel. For this FS, it is assumed that the following equipment utilized in the removal of VOCs from groundwater will be periodically inspected, maintained per manufacturer specification, and replaced (as necessary) over the course of the Alternative 1 project life:

- Air stripping tower (approximate 10 ft diameter; 40 ft height);

- Structural inspection/maintenance.
- Periodic cleaning of unit and packing material and inspection for fouling or corrosion.

- Granular activated carbon (GAC) adsorption vessels and associated piping and equipment (six units, each approximately 1200 gallons in volume).
  - Structural inspection/maintenance.
  - Periodic cleaning of units and inspection for fouling or corrosion.

The following O&M items associated with VOC removal were assumed over the lifetime of the alternative, based on current Bowling Green system information:

- Replacement of spent GAC, including off-site disposal or regeneration;
- Inspection of system piping, pumps, meters, and electrical control components;
- Electricity/power costs;
- Inspection of GAC system and air stripping tower (influent/effluent monitoring; wet chemistry) to ensure that VOC removal criteria are being achieved;
- Miscellaneous administrative activities, including maintenance of discharge (effluent water and air emissions) permits, noise control and aesthetics, worker health and safety, and overall system management.

The Alternative 1 cost estimate is included in Chapter 12.

11.3.2 **Alternative 2: Monitored Natural Attenuation**

Alternative 2, monitored natural attenuation (MNA), refers to the reliance on natural attenuation processes to achieve specific remedial objectives within a reasonable time frame. Natural attenuation processes may include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, and/or concentration of contaminants in the groundwater. Although MNA does not include an active treatment of the contaminated off-site groundwater, it does include the monitoring and evaluation of natural attenuation processes in the subsurface that can diminish contaminant concentrations in groundwater. As discussed above, active source removal and groundwater remediation is in-place or planned at 13 source sites within the NCIA.

Alternative 2 includes institutional controls (e.g., development, and groundwater use restrictions) to minimize contact with the contaminated groundwater. It is also assumed that the Bowling Green Water District will continue to remove VOCs from the groundwater prior to distribution to the water supply system. Groundwater use restrictions will be implemented to prevent development of the underlying groundwater as a potable or a process water source without the necessary water quality treatments, as determined by NYSDEC. If necessary, development restrictions may be used as a means to implementing groundwater use restrictions. Alternative 2 also includes long-term MNA monitoring to identify any migration or changes in the VOC contaminant plumes.

The in-situ, natural attenuation processes may include biological processes such as aerobic or anaerobic biodegradation; physical phenomena such as dispersion, dilution, sorption, and volatilization; and chemical reactions such as hydrolysis and dehydrohalogenation. Natural attenuation processes typically occur at all sites, but to varying degrees of effectiveness depending on the types and concentrations of contaminants present and the physical, chemical, and biological characteristics of the soil and groundwater. Natural attenuation processes may reduce the potential risk posed by site contaminants in three ways:

1. Transformation of contaminants to less toxic forms through destructive processes such as biodegradation or abiotic transformations;
2. Reduction of contaminant concentrations whereby potential exposure levels may be reduced; and
3. Reduction of contaminant mobility and bioavailability through sorption onto the soil or rock matrix (USEPA 1999).

Where conditions are favorable, natural attenuation processes may reduce contaminant mass or concentration at sufficiently rapid rates to be integrated into a program that addresses contamination at a particular site.

MNA has several potential advantages and disadvantages in remediating contamination. Potential advantages of MNA include:

- Some natural attenuation processes may result in in-situ destruction of contaminants;

- Generation of smaller volumes of remediation wastes, reduced potential for cross-media transfer of contaminants (commonly associated with ex-situ treatment), and reduced risk of human exposure to contaminated media;
- There are no significant space requirements as structures or treatment systems are not typically needed;
- Can be used in conjunction with, or as a follow-up to, other (active) remedial measures; and
- Potentially lower overall remediation costs than those associated with active remediation.

Some potential limitations of MNA include:

- Longer time frames may be required to achieve remediation objectives at a given site, compared to active remediation measures;
- Toxicity and/or mobility of transformation products may exceed those of parent compounds;
- Long-term MNA performance monitoring will generally be costly and can continue for long periods of time; and
- Potential exists for continued contamination migration, and/or cross-media transfer of contaminants.

11.3.2.1 ***Site Characterization.*** Because the ability of natural attenuation as an effective remedial alternative depends on a variety of conditions, the site must be well-characterized to determine if natural attenuation is occurring or will occur in the future. Where MNA is being considered as a remedial approach, certain unique aspects of the site may need to be assessed. For example, to assess the contributions of sorption, dilution, and dispersion to natural attenuation of contaminated groundwater, a detailed understanding of aquifer hydraulics, recharge and discharge areas and volumes, and chemical properties is necessary. Where biodegradation will be assessed, characterization also should include evaluation of the nutrients and electron donors and acceptors present in the groundwater, the concentrations of co-metabolites and metabolic by-products, rates of biological transformations, and possibly specific analyses to identify the microbial populations present. The findings of these, and any other analyses pertinent to characterizing natural attenuation processes, are typically incorporated into the creation of a conceptual model of contaminant fate and transport developed for a site (USEPA 1999).

The conceptual site model is generally used to demonstrate the efficacy of MNA at a site by numerically simulating complex attenuation processes that may occur. Other methods are also employed to evaluate the potential efficacy of MNA as a remedial alternative. For instance, the collection of site-specific data can be used to estimate the rate of attenuation processes and the anticipated time required to achieve remediation objectives. A three-tiered approach to an overall evaluation is becoming more widely practiced and accepted (USEPA 1999). This three-tiered approach includes:

1. Historical groundwater and/or soil chemistry data that demonstrate a clear and meaningful trend of decreasing contaminant mass and/or concentration over time at appropriate monitoring or sampling points.
2. Hydrogeologic and geochemical data that can be used to demonstrate indirectly the type(s) of natural attenuation processes active at the site, and the rate at which such processes will reduce contaminant concentrations to required levels. For example, characterization data may be used to quantify the rates of contaminant sorption, dilution, or volatilization, or to demonstrate and quantify the rates of biological degradation processes occurring at a site.
3. Data from field or microcosm studies which directly demonstrate the occurrence of a particular natural attenuation process at the site and its ability to degrade the contaminants of concern (typically used to demonstrate biological degradation processes only).

For the NCIA off-site groundwater, MNA site characterization data were obtained from the January 2000 groundwater sampling events conducted for the RI. A discussion of these data collection activities is included in Chapter 5 of the RI report. In general, laboratory and field data were gathered, as per EPA guidance, so that the effectiveness of MNA to decrease the VOC parameters of concern could be evaluated. As part of the off-site groundwater MNA characterization, 24 groundwater samples were analyzed for VOCs, arsenic, iron (total), manganese, methane, and ethene by a fixed laboratory. Levels of alkalinity, chloride, dissolved oxygen, conductivity, oxidation-reduction potential (ORP), pH, temperature, hardness, and Fe^{2+} were analyzed in the field.

For this FS, the EPA-endorsed software package BioChlor was used to evaluate MNA in the off-site groundwater. BioChlor was developed to screen natural attenuation as a feasible remediation method for a contaminated site and to mathematically model the selected chlorinated solvents within a groundwater plume. BioChlor includes a natural attenuation screening protocol that awards points and scores a particular site based on site-specific characteristics. In addition, BioChlor mathematically models chlorinated solvents in the groundwater plume based on a sequential, first-order, coupled reactive transport model, and analytically solves the model using the Domenico model. The MNA site characterization data from the January 2000 groundwater sampling event were used as input in the BioChlor software, along with historic groundwater data from the NCIA and vicinity, to evaluate the applicability of MNA as an alternative for the off-site groundwater contamination. Historical data were reviewed in order to fill in data gaps in the MNA characterization. Results of the BioChlor analysis are included in Chapter 12. In general, the software indicated that there is limited-to-adequate evidence for natural attenuation of chlorinated solvents in the off-site groundwater. Information on the software is included in Appendix J.

Although hydraulic conductivity has been estimated at the site based on slug test data, Alternative 2 assumes that an aquifer pump test will be conducted as part of site characterization activities to better determine hydraulic conductivity, hydraulic gradient, and other site-specific hydrogeologic parameters.

11.3.2.2 ***Long-Term MNA Monitoring.*** Performance monitoring to evaluate remedy effectiveness and to ensure protection of human health and the environment is a critical element of all response actions. Performance monitoring is of even greater importance for MNA than for other types of remedies due to the potentially longer remediation timeframes, potential for ongoing contaminant migration, and other uncertainties associated with using MNA.

In general, the monitoring program developed should specify the location, frequency, and type of samples and measurements necessary to evaluate whether natural attenuation processes are performing as expected and are capable of attaining remediation objectives. The monitoring program for the NCIA off-site groundwater should be designed to accomplish the following:

- Demonstrate that natural attenuation is occurring according to expectations;

- Detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological, or other changes) that may reduce the efficacy of any of the natural attenuation processes;
- Identify any potentially toxic and/or mobile transformation products;
- Verify that the plume is not expanding (either downgradient, laterally, or vertically);
- Document any impact to downgradient receptors;
- Detect new releases of contaminants to the environment; and
- Verify attainment of remediation objectives.

The frequency of monitoring should be adequate to detect, in a timely manner, the potential changes in site conditions listed above. At a minimum, the monitoring program should be sufficient to enable a determination of the rate(s) of attenuation and how the rate is changing with time. When determining attenuation rates, the uncertainty in these estimates and the associated implications should be evaluated. Flexibility for adjusting the monitoring frequency over the life of the remedy should also be included in the monitoring plan. For example, it may be appropriate to decrease the monitoring frequency at some point in time, once it has been determined that natural attenuation is progressing as expected and very little change is observed from one sampling round to the next. In contrast, the monitoring frequency may need to be increased if unexpected conditions (e.g., plume migration) are observed. Performance monitoring should continue until remediation objectives have been achieved, and longer if necessary to verify that the site no longer poses a threat to human health or the environment.

During the natural attenuation process, there is the potential for the creation of transformation products that are more toxic than the parent contaminant (e.g., degradation of PCE to vinyl chloride). Additionally, some natural attenuation processes may result in the transfer of some contaminants from one medium to another. Thus, proper monitoring needs to be implemented to assess the formation of more toxic by-products or if cross-media contamination takes place.

The duration of a MNA alternative is determined from natural attenuation evaluation and regulatory requirements. It should be noted that the timeframe required for MNA remedies is often longer than that required for more active remedies. As a consequence, the uncertainty associated with factors used in developing MNA timeframes increases dramatically. Adequate performance evaluation monitoring and contingency remedies may need to be utilized because of this higher level of uncertainty. When determining reasonable timeframes, the uncertainty in the estimations should be considered, as well as the ability to establish performance monitoring programs capable of verifying the timely performance anticipated from natural attenuation.

For the purposes of this FS, the long-term MNA monitoring program is assumed to test for and track the following parameters:

- VOCs (and potential transformation products);
- Total organic carbon (TOC);
- Carbon dioxide (CO_2);
- Electron acceptors (dissolved oxygen, nitrate [NO_3^-], sulfate [SO_4^{2-}], Fe^{2+}, CH_4);
- Alkalinity;
- Redox potential (Eh);
- Chloride; and
- pH, temperature, and conductivity.

VOCs (including potential VOC transformation products), TOC, CO_2, nitrate, sulfate, methane, and chloride, will be analyzed at an analytical laboratory; the remaining parameters listed above will be measured in the field. Following a detailed analysis of the data produced from the January 2000 MNA site characterization program, some of the above-listed parameters may be dropped from the sampling schedule if they are not important to the long-term monitoring program (i.e., if the parameters are not found to be significant indicators of natural attenuation processes).

The purpose of the long-term MNA monitoring program included in this alternative is to monitor any migration and natural attenuation of the on-site contaminant plume. Table 11-2 summarizes the proposed monitoring program for the performance evaluation of natural attenuation at the site. The 14 existing wells included were chosen to provide data from within the shallow, intermediate, and deep portions of the off-site contaminant plumes and from locations within and downgradient of the area of contamination.

TABLE 11-2

ALTERNATIVE 2
MONITORED NATURAL ATTENUATION
LONG-TERM MONITORING PROGRAM SUMMARY [1]
Natural Attenuation Monitoring
NCIA Off-Site Groundwater

WELL[2]	Plume Location	DEPTH[3]	SAMPLING SCHEDULE[4] YEARS 1-5	SAMPLING SCHEDULE[5] YEARS 6-30
N-10477	West	57 ft (shallow)	X	X
N-10478	West	121 ft (intermediate)	X	X
N-11851	West	65 ft (shallow)	X	X
NRMW-4	West	70 ft (intermediate)	X	X
N-11848	West	60 ft (shallow)	X	X
N-11860	Central	60 ft (shallow)	X	X
N-11862	Central	60 ft (shallow)	X	X
N-10476	Central	130 ft (deep)	X	X
N-11861	Central	60 ft (shallow)	X	X
NRMW-1	Central/East	70 ft (intermediate)	X	X
EW-1B	Central/East	164 ft (deep)	X	X
EW-1C	Central/East	516 ft (deep)	X	X
N-9939	Central/East	74 ft (intermediate)	X	X
N-10329	East	57 ft (shallow)	X	X
		TOTAL:	**14**	**14**

X - Sampling is recommended.
- Natural attenuation monitoring entails sampling and analyzing groundwater for the following parameters:
<u>Field Measurements</u>: pH, temperature, conductivity, iron(II), redox potential, dissolved oxygen, and alkalinity.
<u>Laboratory Analyses</u>: VOCs (potential transformation products), total organic carbon, carbon dioxide, nitrate, sulfate, methane, and chloride.

1 - This is a preliminary monitoring program developed for cost estimation purposes; the final monitoring program will be established during the remedial design phase; depending on the sample results, the schedule may be modified.
2 - Well locations are depicted on Figures 3-4, 3-5, and 3-6 of the RI report.
3 - Shallow groundwater exists at depths between the water table and 64-ft; intermediate groundwater exists from approximately 65-124 ft bgs. deep groundwater exists at depths of 125 ft bgs or greater.
4 - All samples will be analyzed for VOCs quarterly.
5 - All samples will be analyzed for VOCs annually.

Table 11-3 lists the 16 existing wells and six new monitoring well couplets selected for long-term monitoring of the VOC contaminant plume. All wells are depicted in Figure 11-2. The dimensions of the plume area and VOC concentrations (e.g., PCE, TCE) in the groundwater will be assessed over time to evaluate the effectiveness of natural attenuation at the site.

A rough time frame of 30 years for the MNA alternative was estimated for the off-site groundwater, considering the maximum concentrations of each of the VOCs detected in the off-site groundwater plumes, half-lives of the contaminants in groundwater (as found in literature reviews), and the assumption that Class GA groundwater standards are to be achieved. This estimation was not considered to be precise since only simple, first-order degradation calculations were made and no modeling was conducted. In addition, the formation of transformation products that would be expected from the degradation of VOCs was not assessed. As the calculation for TCE yielded the longest time period to meet the groundwater standard, it was used to estimate the overall time frame of the MNA alternative. The calculation for TCE is shown below.

TCE: *Initial maximum concentration:* 1800 ug/l
Groundwater standard (assumed remedial objective): 5 ug/l
Average half-life (days): 987 days

Days	Years	Concentration (ug/l)
0	0	1800
987	2.7	900
1974	5.4	450
2961	8.1	225
3948	10.8	112.5
4935	13.5	56.25
5922	16.2	28.13
6909	18.9	14.06
7896	21.6	7.03
8883	24.3	3.51

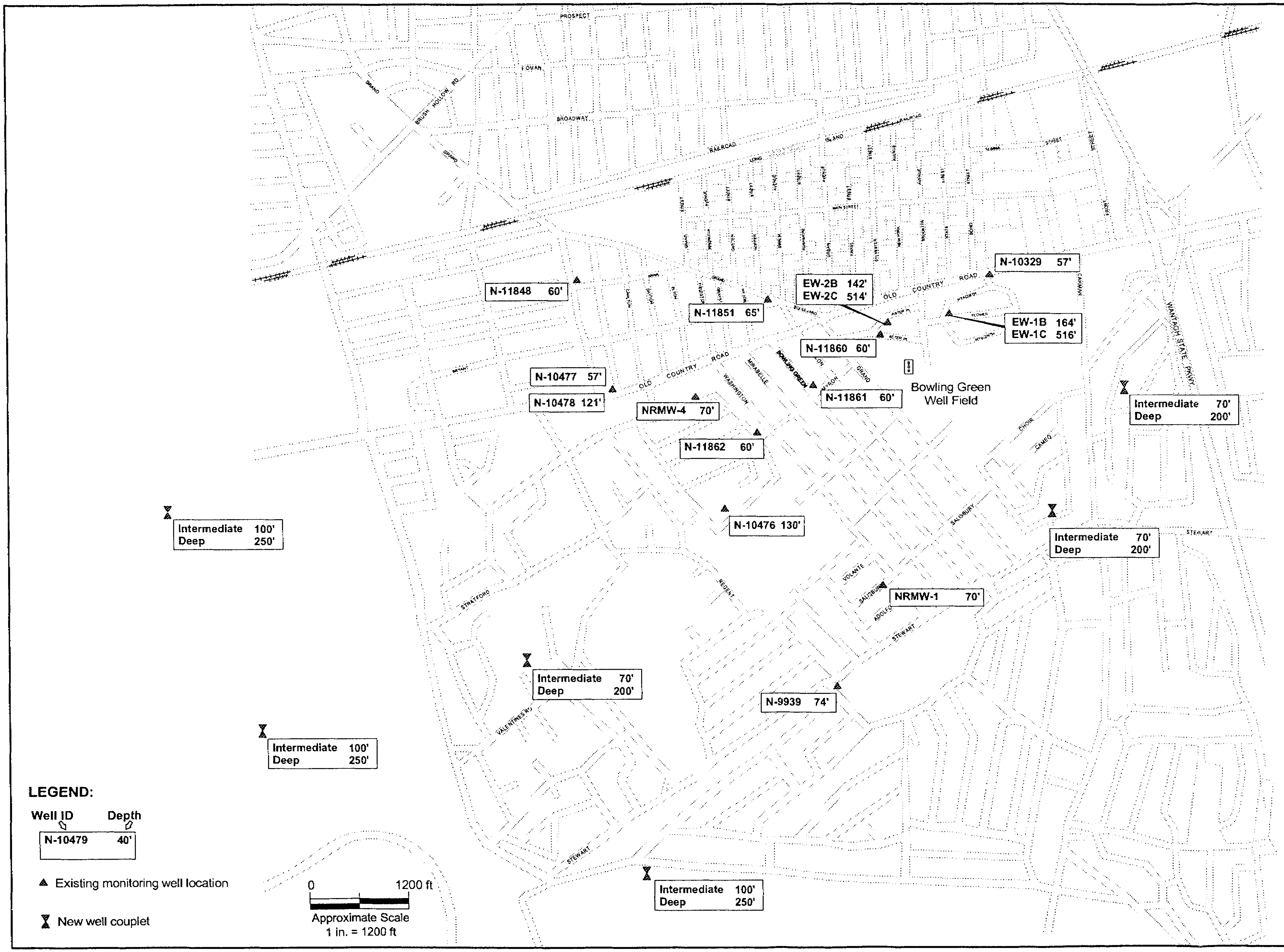


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Figure 11-2

Off-site Groundwater Long-Term Monitoring and Sampling Wells

OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
NYSDEC I.D. No. 130043

LAWLER, MATUSKY & SKELLY ENGINEERS LLP
Pearl River, New York

TABLE 11-3

ALTERNATIVE 2
MONITORED NATURAL ATTENUATION
LONG-TERM MONITORING PROGRAM SUMMARY [1]
Contaminant Plume Monitoring
NCIA Off-Site Groundwater

WELL[2]	Plume Location	DEPTH [3]	SAMPLING SCHEDULE [4] YEARS 1-5	SAMPLING SCHEDULE [5] YEARS 6-30
N-10477	West	57 ft (shallow)	X	X
N-10478	West	121 ft (intermediate)	X	X
N-11851	West	65 ft (shallow)	X	X
NRMW-4	West	70 ft (intermediate)	X	X
N-11848	West	60 ft (shallow)	X	X
N-11860	Central	60 ft (shallow)	X	X
N-11862	Central	60 ft (shallow)	X	X
N-10476	Central	130 ft (deep)	X	X
N-11861	Central	60 ft (shallow)	X	X
EW-1B	Central/East	164 ft (deep)	X	X
EW-1C	Central/East	516 ft (deep)	X	X
EW-2B	Central/East	142 ft (deep)	X	X
EW-2C	Central/East	514 ft (deep)	X	X
NRMW-1	Central/East	70 ft (intermediate)	X	X
N-9939	Central/East	74 ft (intermediate)	X	X
N-10329	East	57 ft (shallow)	X	X
6 proposed new well couplets[6]		**intermediate/deep**	X	X
		TOTAL:	**28**	**28**

X - Sampling is recommended.
1 - This is a preliminary monitoring program developed for cost estimation purposes; the final monitoring program will be established during the remedial design phase; depending on the sample results, the schedule may be modified.
2 - Well locations are depicted on Figures 3-4, 3-5, and 3-6 of the RI report.
3 - Shallow groundwater exists at depths between the water table and 64-ft; intermediate groundwater exists from approximately 65-124 ft bgs. deep groundwater exists at depths of 125 ft bgs or greater.
4 - All samples will be analyzed for VOCs semi-annually.
5 - All samples will be analyzed for VOCs annually.
6 - For costing purposes, it is assumed that 6 new monitoring well locations will be established at locations downgradient and sidegradient of existing off-site plumes to monitor future VOC migration. It is assumed that monitoring wells will be installed at intermediate and deep depths as follows:
A total of 3 intermediate wells will be installed to 70 ft bgs. the remaining 3 intermediate wells are to be installed to a depth of 100 ft bgs.
A total of 3 deep wells will be installed to 200 ft bgs. the 3 remaining deep wells are to be installed to a depth of 250 ft bgs.

This estimate is believed to be conservative since the maximum contaminant concentration found in the plumes (1800 ug/l) was retained for the calculation. The chemical-specific half-life values were derived from scientific judgment based on hydrolysis half-life and anaerobic sediment grab sample data (Howard et al, 1991). Based on the findings for TCE, it is assumed (conservatively) that remedial objectives may be obtained in approximately 8,883 days or about 24 years (as a comparison, 1,1-DCE, yielded a time frame of approximately 2 years). An additional six years for a total of 30 was assumed to be conservative in estimating the total time to remediate the off-site plumes; however, the actual remediation timeframe under this alternative may be more than 30 years. The assumption of a 30-yr MNA monitoring program also allowed for cost comparisons among the other alternatives. The natural attenuation monitoring will be conducted on a quarterly basis (to assess possible seasonal fluctuations in subsurface parameters and natural attenuation processes) for the first five years and annually for years 6 through 30. VOC contaminant monitoring will be conducted on a semiannual basis for the first five years and annually from year 6 on. The need for such monitoring programs may be re-evaluated and possibly altered at any time during the 30-year period. For instance, if groundwater contaminant levels remain below the site remedial action objectives for five consecutive years, the monitoring program may be considered for discontinuation. If contaminant levels continue to exceed the remedial action objectives at the end of the 30-yr period, the monitoring program may be extended, or other remedial actions taken. If contaminant levels do not decline during the initial years of MNA, a requirement for additional remediation may be imposed.

Although a 30-yr time frame has been assumed for comparison purposes, a number of factors should be addressed in the detailed final design of the monitoring program to help define what is a reasonable time frame for long-term monitoring of natural attenuation to take place in the off-site groundwater plumes. For example, records of contaminant concentrations over time will be kept and periodically evaluated to monitor trends. Uncertainties regarding the mass of contaminants in the subsurface and predictive analyses (e.g., remediation timeframe, travel time for contaminants to reach downgradient points of exposure appropriate for the area) will be assessed. In addition, factors relating to the affected drinking water resources and institutional controls shall also be monitored. Data can be integrated into a site model to more accurately assess natural attenuation at the site. The final design may also better define the locations and number of wells to be included in the long-term MNA monitoring program.

The cost estimate for this long-term groundwater monitoring program (provided in Chapter 12) assumes replacement of three of the monitoring wells being sampled every five years during the 30 years of monitoring. The replacement cost is necessary because a monitoring well could become plugged, the casing could collapse, or the well could be damaged. Replacement costs of the four "Early Warning" wells (EW-1B, EW-1C, EW-2B, and EW-2C) are not included in the cost estimates. In addition, the cost estimate developed for this alternative assumes operation and maintenance, including replacement of equipment as needed, of the VOC treatment processes that are currently in-place at the Bowling Green Water District (refer to Alternative 1).

11.3.3 **Alternative 3: Monitoring, Assessment, and Contingent Remediation**

As described above, active contaminant source removal and groundwater remediation is in-place or planned at 13 source sites within the NCIA. Alternative 3, Monitoring, Assessment, and Contingent Remediation, combines continued active contaminant source removal and groundwater remediation with a long-term groundwater monitoring program, and a contingency plan to provide for active treatment of the off-site contaminant plumes should the long-term monitoring program show this to be necessary. Alternative 3 also includes institutional controls in the form of development and groundwater use restrictions. In addition, it is assumed that the Bowling Green Water District will continue to remove VOCs from the groundwater prior to distribution to the water supply system. Groundwater use restrictions will be implemented to prevent development of the underlying groundwater as a potable or a process water source without necessary water quality treatment as determined by NYSDEC. Under Alternative 3, groundwater quality as determined by the long-term monitoring program will be reviewed on an annual basis to determine what remediation is required. If it is determined that remediation is required, Alternative 5A: Remediation of Upper and Deep Portions of Aquifer (to 200 ft bgs) with In-Well Vapor Stripping / Localized Vapor Treatment will be implemented.

11.3.3.1 ***Long-Term Groundwater Monitoring.*** The purpose of the long-term groundwater monitoring program included in this alternative is to monitor any migration of the off-site contaminant plumes. Existing monitoring wells selected for the long-term monitoring for Alternative 3 are listed in Table 11-4 and shown in Figure 11-2. In

TABLE 11-4

ALTERNATIVE 3
MONITORING PROGRAM SUMMARY [1]
NCIA Off-Site Groundwater

WELL[2]	Plume Location	DEPTH[3]	SAMPLING SCHEDULE[4] YEARS 1-5	SAMPLING SCHEDULE[5] YEARS 6-30
N-10477	West	57 ft (shallow)	X	X
N-10478	West	121 ft (intermediate)	X	X
N-11851	West	65 ft (shallow)	X	X
NRMW-4	West	70 ft (intermediate)	X	X
N-11848	West	60 ft (shallow)	X	X
N-11860	Central	60 ft (shallow)	X	X
N-11862	Central	60 ft (shallow)	X	X
N-10476	Central	130 ft (deep)	X	X
N-11861	Central	60 ft (shallow)	X	X
EW-1B	Central/East	164 ft (deep)	X	X
EW-1C	Central/East	516 ft (deep)	X	X
EW-2B	Central/East	142 ft (deep)	X	X
EW-2C	Central/East	514 ft (deep)	X	X
NRMW-1	Central/East	70 ft (intermediate)	X	X
N-9939	Central/East	74 ft (intermediate)	X	X
N-10329	East	57 ft (shallow)	X	X
6 proposed new well couplets[6]		***intermediate/deep***	X	X
		TOTAL:	**28**	**28**

X - Sampling is recommended.
1 - This is a preliminary monitoring program developed for cost estimation purposes; the final monitoring program will be established during the remedial design phase; depending on the sample results, the schedule may be modified.
2 - Well locations are depicted on Figures 3-4, 3-5, and 3-6 of the RI report.
3 - Shallow groundwater exists at depths between the water table and 64-ft, intermediate groundwater exists from approximately 65-124 ft bgs, deep groundwater exists at depths of 125 ft bgs or greater.
4 - All samples will be analyzed for VOCs semiannually.
5 - All samples will be analyzed for VOCs annually.
6 - For costing purposes, it is assumed that 6 new monitoring well locations will be established at locations downgradient and sidegradient of existing off-site plumes to monitor future VOC migration. It is assumed that monitoring wells will be installed at intermediate and deep depths as follows:
A total of 3 intermediate wells will be installed to 70 ft bgs; the remaining 3 intermediate wells are to be installed to a depth of 100 ft bgs.
A total of 3 deep wells will be installed to 200 ft bgs; the 3 remaining deep wells are to be installed to a depth of 250 ft bgs.

addition, it was assumed that twelve additional wells (i.e., six intermediate and deep well couplets) will also be installed for this alternative for the monitoring program. The monitoring program (developed here for cost estimating purposes) includes a total of 28 monitoring wells (16 existing and 12 new wells ranging in depth from 57 to 516 ft bgs) at locations south of the NCIA. Wells were selected to represent comprehensive (i.e., downgradient of and within the off-site contamination) monitoring of the plume areas and depths. The 16 existing monitoring wells were selected for the long-term monitoring program as they are situated at various locations and depth intervals within the three off-site plumes. The locations of the new intermediate/deep monitoring well couplets will be within and downgradient of the existing off-site plumes, including at locations in the immediate upgradient vicinity of the Bowling Green supply wells.

At the end of every year, a technical assessment of groundwater data will be conducted to determine what remediation is required. Based on those findings of the technical evaluation, the monitoring program will be continued, discontinued, or amended as to number of wells and frequencies of monitoring. Based on the findings from the remedial option assessment, decisions will also be made as to the implementation of active groundwater remediation. If it is determined that remediation is required, Alternative 5A will be implemented. For cost estimating purposes, data reduction/maintenance and technical analyses are considered for the first five years in Alternative 3.

An overall 30-yr monitoring program (as described in Table 11-4) has been assumed for Alternative 3 in order to allow for cost comparisons among the other alternatives. If contaminant levels continue to exceed the remedial action objectives at the end of the 30-yr period, the monitoring program may be extended, or other remedial actions taken. In costing this alternative, it was assumed that the existing monitoring wells and the twelve additional wells noted above will be sufficient to assess the long term effects of the groundwater plume.

Although a 30-yr time frame has been assumed for comparison purposes, a number of factors should be addressed in the detailed design of the monitoring program to help define what is a reasonable time frame for long-term monitoring of the off-site groundwater. For instance, records of contaminant concentrations over time will be kept and evaluated yearly to monitor trends. Uncertainties regarding the mass of contaminants in the subsurface and predictive analyses (e.g., remediation timeframe, travel time for contaminants to reach downgradient points of exposure appropriate for the area) will also be assessed. In addition, factors relating to the affected drinking water resource and institutional controls will also be monitored. The cost estimate for this long-term groundwater monitoring program (provided in Chapter 12) assumes replacement of three of the monitoring wells being sampled every five years during the assumed 30 years of monitoring. The replacement cost is necessary because a monitoring well could become plugged, the casing could collapse, or the well could be damaged. Replacement costs of the four "Early Warning" wells (EW-1B, EW-1C, EW-2B, and EW-2C) are not included in the cost estimates. In addition, the cost estimate developed for this alternative assumes operation and maintenance, including replacement of equipment as needed, of the VOC treatment processes that are currently in-place at the Bowling Green Water District (refer to Alternative 1).

11.3.4 **Alternative 4A: Remediation of Upper Portion of Aquifer (to 125 ft bgs) with In-Well Vapor Stripping / Localized Vapor Treatment**

Alternative 4A includes remediating the upper portion (i.e., at depths from the water table to 125 ft bgs) of the off-site groundwater contaminant plumes by implementing in-well vapor stripping, an in-situ remediation technology, and localized off-gas treatment. This alternative also includes long-term monitoring of the groundwater plumes. As discussed above, active source removal and groundwater remediation is in-place or planned at 13 source sites within the NCIA.

The reported advantages of using the in-well vapor stripping technology over other methods for remediating contaminated groundwater include:

- Cost savings because there is no need to pump, handle, and treat groundwater at the surface; only contaminated vapor is extracted and treated in this technology.
- System can be designed so that soils in the unsaturated zone do not become incidentally or temporarily contaminated during groundwater remediation.
- Simplicity of design.
- The system can be designed to run continuously with only routine maintenance.

Some limitations reported for this technology include:

- Possible clogging of well screens due to biofouling and precipitation of iron or other nutrients present in the subsurface.
- Lower effectiveness in shallow aquifers (due to limited area for groundwater recirculation).

Several commercial variations of the in-well vapor stripping process have been developed. Three main types of in-well vapor stripping systems include the Unterdruck-Verdampfer-Brunnen (UVB) or "vacuum vaporizer well" system, the NoVOCs™ system, and the Density Driven Convection (DDC) system. All three systems can achieve remedial objectives for the off-site groundwater. For purposes of this FS, the UVB in-well vapor stripping system was selected for analysis and costing of the in-well vapor stripping alternatives. The UVB system was chosen for several reasons:

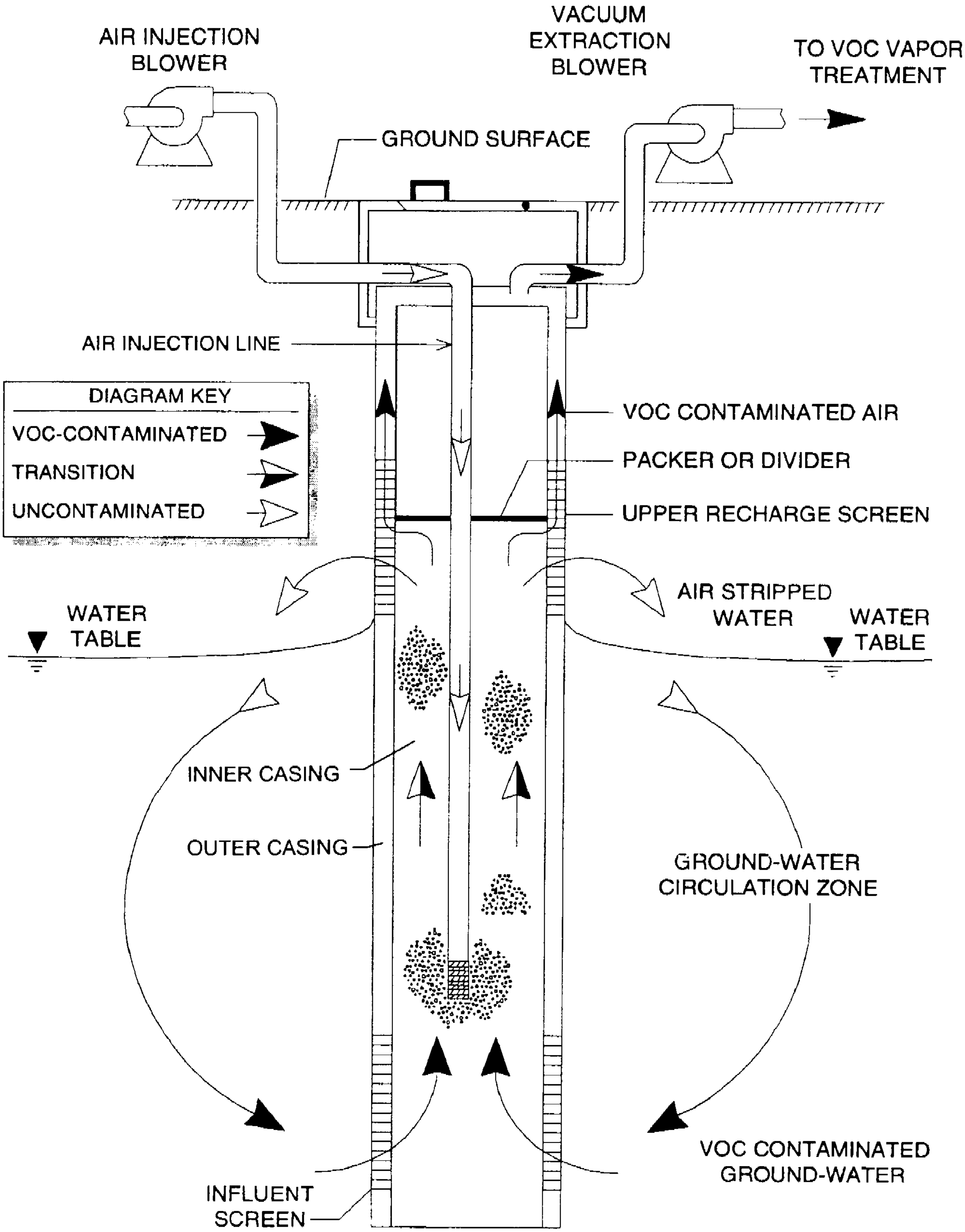
- The large amount of information and research readily available in the literature.
- Flexibility of the system to operate under various site conditions.
- Decreased moisture content in vapors to be treated.
- Lower likelihood of well screens to become clogged by iron and other precipitates.
- Previous demonstration at sites with other physical and contaminant characteristics similar to the NCIA off-site area.

System and cost information for an alternate in-well vapor stripping technology, DDC, was obtained. A sensitivity analysis of the UVB and DDC in-well vapor stripping technologies is provided in Appendix K.

11.3.4.1 ***In-Well Vapor Stripping.*** In-well vapor stripping (also known as in-situ vacuum, vapor, or air stripping) is a demonstrated in-situ physical/chemical treatment alternative for remediating contaminated groundwater, as per EPA's Superfund Innovative Technology Evaluation (SITE) program. The technology involves the creation of groundwater circulation patterns, or "cells", in the subsurface surrounding specially designed wells and simultaneous aeration within the wells to volatilize VOCs from the circulating groundwater. Contaminated vapors are typically extracted from the wells and treated at the surface; however, unlike conventional groundwater remediation systems, in-well vapor stripping does not require groundwater to be pumped to and treated at the surface. This in-well air stripping technology is most applicable to VOCs (such as PCE and TCE); however, modifications of the basic remedial process are proposed for applications to treat SVOCs, pesticides, and inorganics. In-well vapor stripping has been used in unconfined and confined aquifers and applied to geologic materials with a range of characteristics. A schematic of the in-well vapor stripping process is shown in Figure 11-3.

An in-well stripping well consists of an inner and an outer casing that are hydraulically separated from one another, usually by a packer or divider plate. This separation ensures one-directional flow of groundwater into the well at its base (through a lower screened interval) and out of the well near the water table (through an upper screened interval). Air is injected into the well through a gas injection line and diffuser, releasing bubbles into contaminated groundwater in the well. These bubbles aerate the water and form a type of air-lift pumping system (due to an imparted density gradient) that causes groundwater to flow upward in the well. As the bubbles rise, VOC compounds in the water are transferred from the dissolved state to the vapor state through an air stripping process.

The air/water mixture rises in the well until it encounters the dividing device within the inner casing. The divider is designed and located within the well to maximize volatilization. The air/water mixture flows from the inner casing to the outer casing through the upper screen. A vacuum is applied in the outer casing, and contaminated vapors are drawn upward through the annular space between the two casings and typically treated at the ground surface. The partially treated groundwater, from which some of the VOCs have been removed, re-enters the subsurface through the upper screen and infiltrates back to the aquifer and the zone of contamination where it is eventually cycled back into the well. This pattern of groundwater movement forms a circulation cell in the subsurface around the well that allows groundwater to undergo sequential treatment cycles until remedial objectives are achieved. A continuous VOC-rich vapor stream is created as contaminant concentrations in groundwater are significantly reduced.



Source: GWRTAC, 1997.

\650-428 NCIA FS\graphics\vaporstrippingdiagram.dsf

LMS Lawler, Matusky & Skelly Engineers LLP One Blue Hill Plaza • Pearl River, New York 10965 ENVIRONMENTAL SCIENCE & ENGINEERING CONSULTANTS	**In-Well Vapor Stripping Process** **NEW CASSEL INDUSTRIAL AREA**	**Figure 11-3**

For the NCIA off-site groundwater, Alternative 4A includes the treatment of the contaminated groundwater to a depth of approximately 125 ft bgs via in-well vapor stripping wells. This alternative addresses "hot-spot" areas within the off-site contaminant plumes and assumes that natural attenuation will remediate a portion of the off-site groundwater over time. As discussed above, active source removal and groundwater remediation is in-place or planned at 13 source sites within the NCIA. Alternative 4A includes the installation of four (4) circulation/stripping wells (8-in. diameter) to address the off-site groundwater contamination, based on contaminant depths and radii of influence expected to be achieved at each well. Figure 11-4 shows approximate locations of the stripping wells for Alternative 4A.

As depicted, two different stripping well configurations will be used in Alternative 4A, based on conversations with a vender of this technology. A total of one 80-ft bgs and three 125-ft bgs wells will be installed within the off-site plumes, at areas of high VOC concentrations. Each well will be mounted flush with the existing ground surface and installed to varying depths, as indicated above. The vertical distances between the screened intervals in the 80-ft wells and 125-ft wells are estimated at 20 ft and 55 ft, respectively. Figure 11-5 displays the average total VOC concentration contours for groundwater depths of 65 to 125 ft bgs (from years 1996 – 2000). Figure 11-6 shows the proposed treatment wells for Alternative 4A, along with approximate radii of influence. A summary of the in-well vapor stripping system components is included in Table 11-5.

Based on the treatment technology and aquifer characteristics in the off-site area, the estimated groundwater flow rate in the 80-ft treatment well is 40 gpm, and the flow rate in the 125-ft wells is 10 gpm. According to venders of the in-well vapor stripping technology, the following radii of influence can be achieved for each type of stripping well in Alternative 4A: 80-ft well: 120 ft; and 125-ft well: 250 ft (refer to Figure 11-6).

Pilot studies (see below) and field measurements in the design phase of work will more accurately determine the construction details and placement of each of the in-well vapor stripping wells in Alternative 4A, along with the specific groundwater circulation/treatment patterns expected to result.

Alternative 4A components of the in-well vapor stripping system include: air injection blowers and vacuum extraction blowers (for vapor collection) and associated piping;

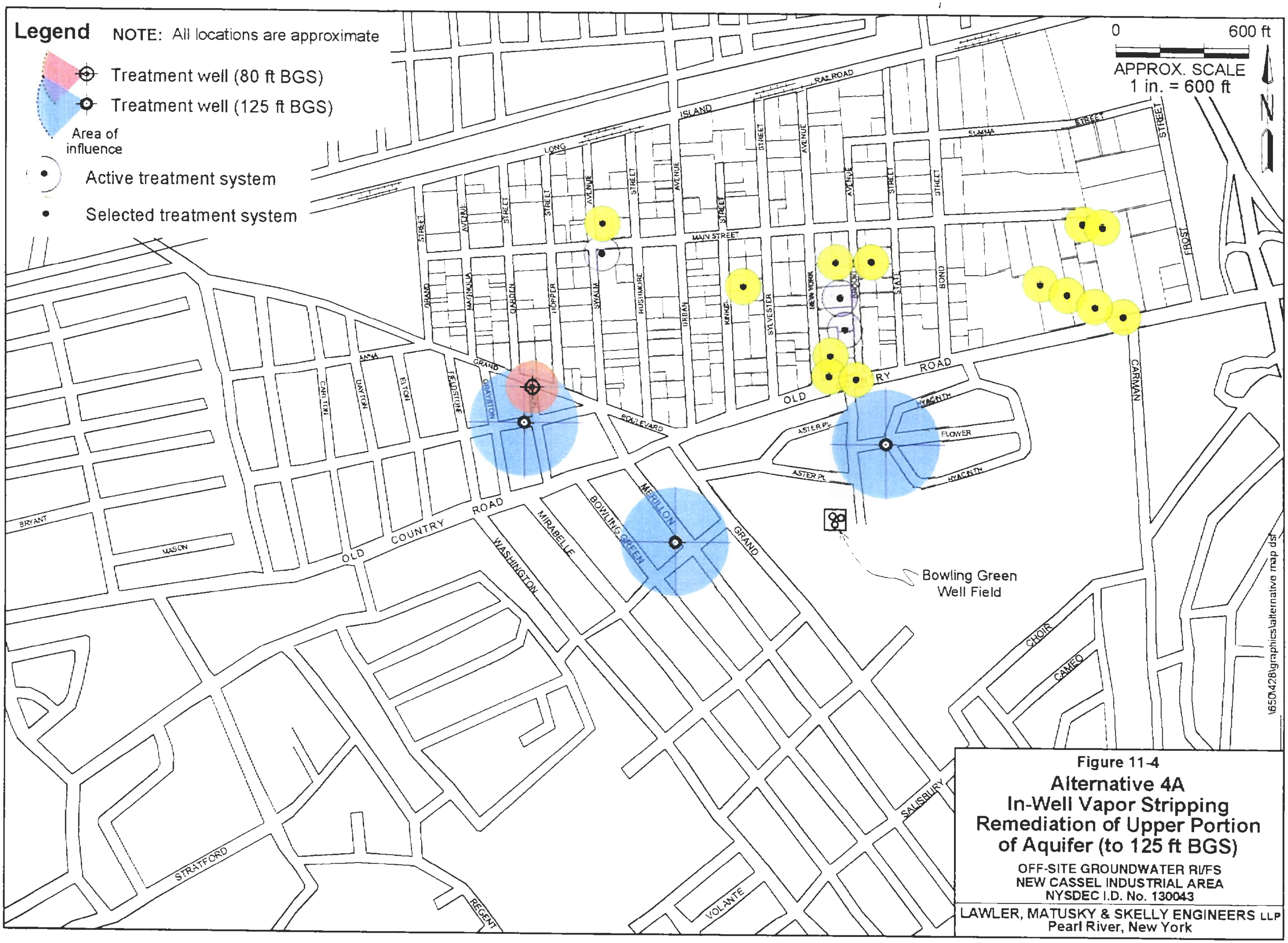


Figure 11-4
Alternative 4A
In-Well Vapor Stripping
Remediation of Upper Portion
of Aquifer (to 125 ft BGS)

OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
NYSDEC I.D. No. 130043

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Pearl River, New York

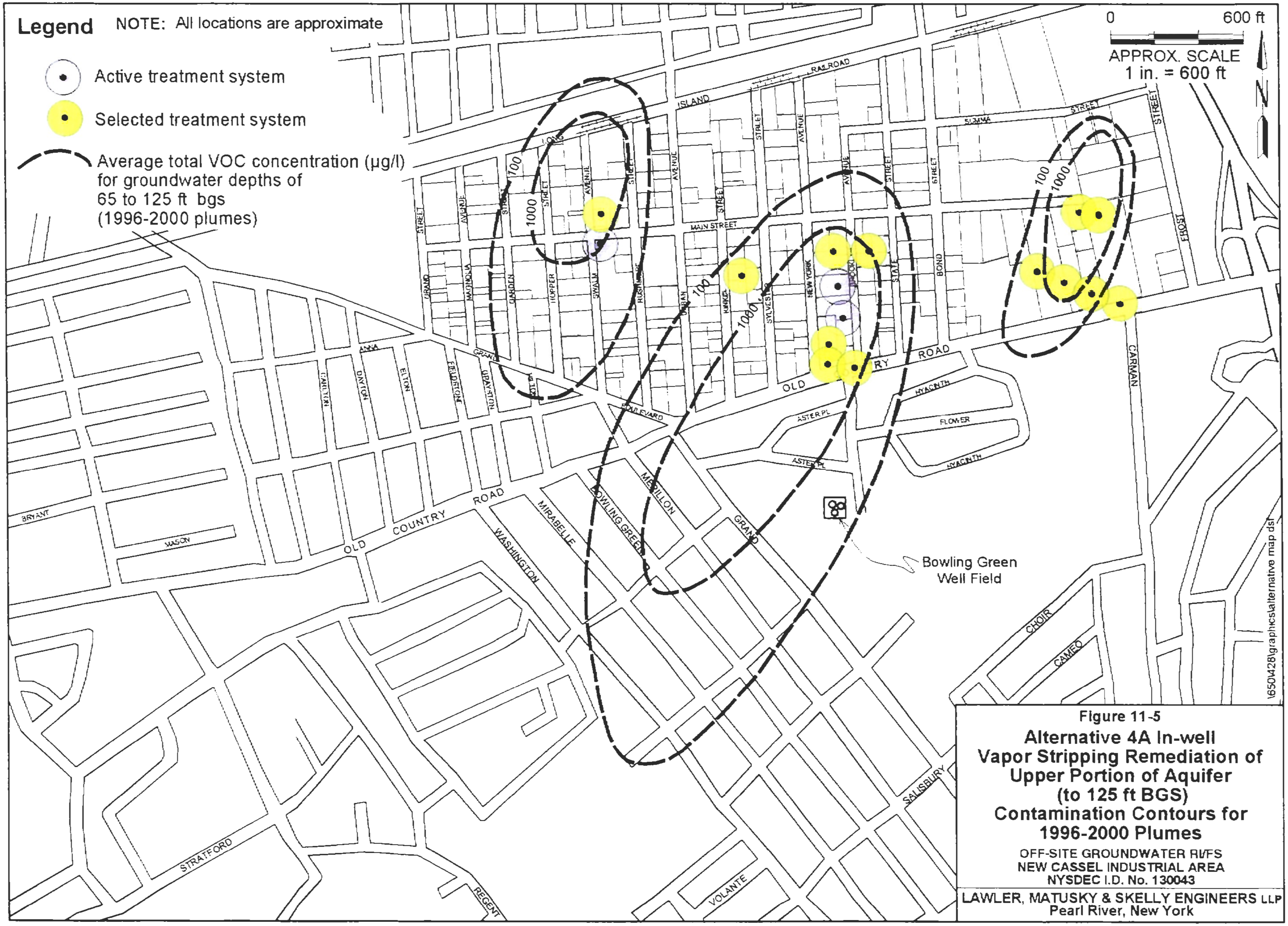

Figure 11-5
Alternative 4A In-well Vapor Stripping Remediation of Upper Portion of Aquifer (to 125 ft BGS) Contamination Contours for 1996-2000 Plumes

OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
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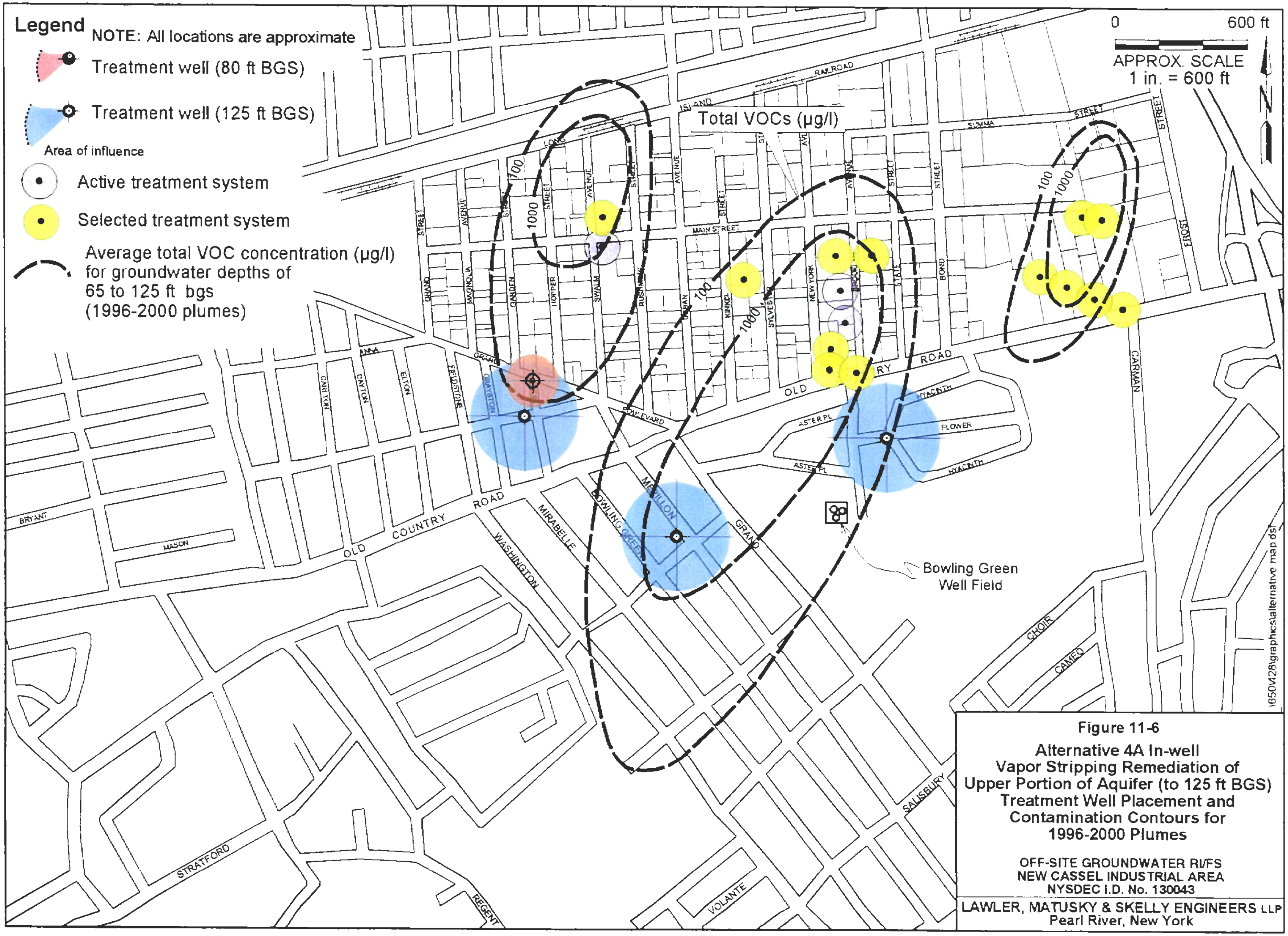

Figure 11-6

Alternative 4A In-well Vapor Stripping Remediation of Upper Portion of Aquifer (to 125 ft BGS) Treatment Well Placement and Contamination Contours for 1996-2000 Plumes

OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
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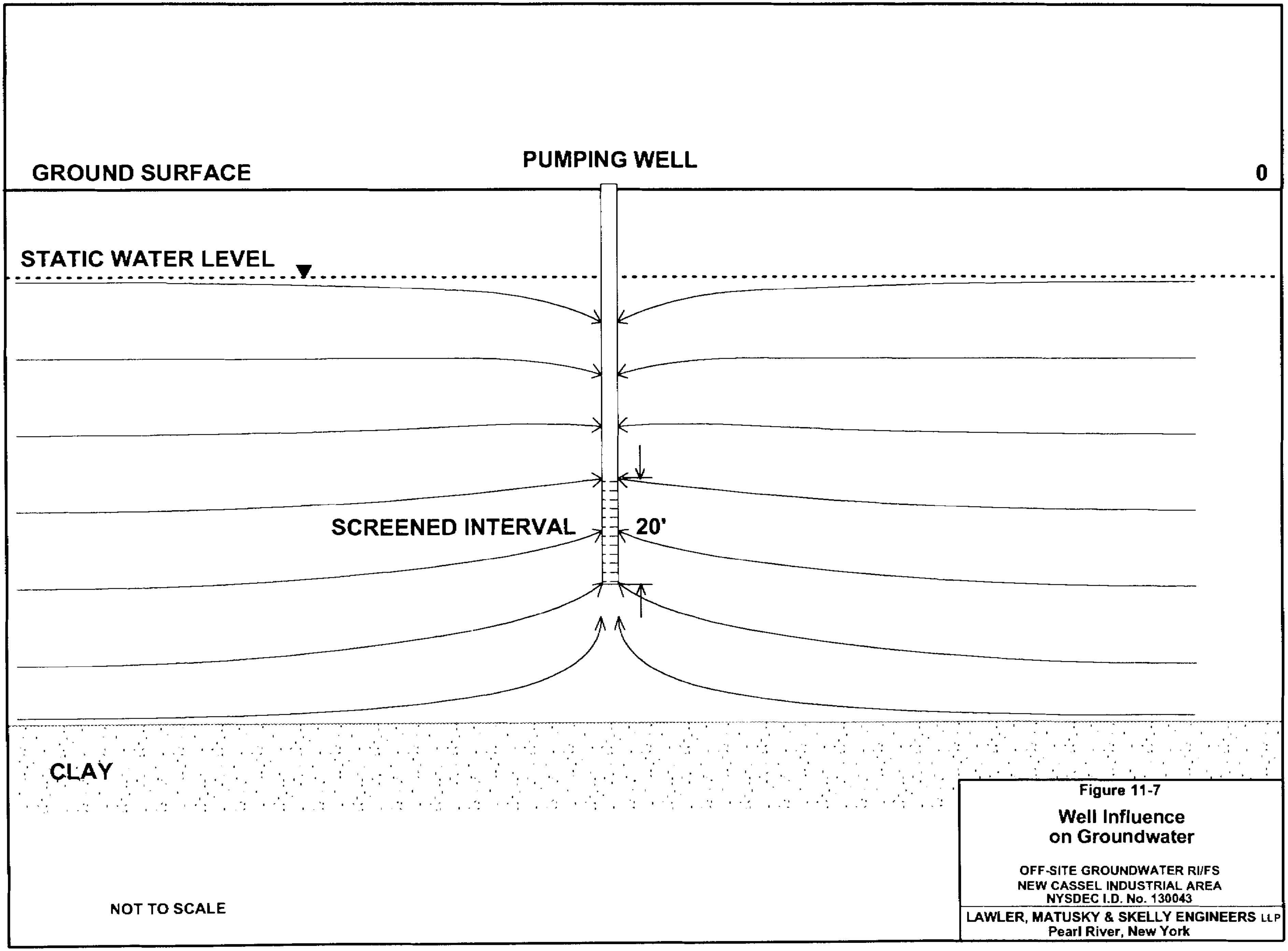

Figure 11-7

Well Influence on Groundwater

OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
NYSDEC I.D. No. 130043

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diameter [steel construction], with pumping rates of 20 gpm and screened intervals of 90 to 110 ft bgs) and one 80-ft extraction well (6-in. diameter [steel construction], with a pumping rate of 40 gpm and a screened interval of 60 to 80 ft bgs) will be installed. All extraction wells will be mounted flush with the existing ground surface. Figure 11-7 shows a cross-section of a typical extraction well. Figure 11-8 shows approximate locations of the extraction wells for Alternative 4B. On Figure 11-8, average total VOC plumes, derived from plume maps for groundwater depths between 65 and 125 ft bgs, are also shown. The wells were located based on the natural direction of groundwater flow and hydraulic conductivity. The 80-ft extraction well was situated to assist in remediating the elevated VOC levels in the western plume.

Each 20 gpm pumping well will contain a 1.5 hp pump with a 1.5-in. outlet. The 40 gpm pumping well will contain a 3 hp pump with a 2-in. outlet. The contaminated groundwater for Alternative 4B will be collected and transferred to a centralized treatment facility from each extraction well via subsurface pipelines. The groundwater will be metered and the flow regulated, ensuring that each pumping well is operating efficiently. This approximately 3200 sf treatment facility will likely be located to the east of the Bowling Green supply wells, as depicted in Figure 11-8.

An estimate of the remediation time was calculated based on assumptions in aquifer characteristics, well placement, flow rates, and contaminant properties. An estimated timeframe for active remediation of 9 years was used for Alternative 4B. Because of the uncertainty in the hydrological parameters (i.e., hydraulic conductivity), the results of this estimation should be confirmed in the design phase, after an aquifer pump test and a pilot study have been completed. In addition, the pilot study can also help identify potential impacts of the extraction wells on the Bowling Green supply wells or other remediation systems (i.e., within the NCIA).

11.3.5.2 ***Groundwater Treatment and Discharge.*** In order to satisfy SCGs, specifically groundwater treatment effluent criteria, the extracted groundwater must be treated to remove groundwater contaminants. Potentially relevant criteria that may apply to discharges of treated water to the groundwater include NYS Groundwater Effluent Limitations (Class GA), SPDES requirements, and EPA's UIC Program criteria (refer to Chapter 7). Prior to the final design of the remediation system, the relevant portions of these SCGs should be agreed upon by all local, state, and Federal agencies, as

Table 11-7

PUMP AND TREAT SUMMARY
NCIA Off-Site Groundwater

	TOTAL FLOW (gpm)	ACTIVE REMEDIATION TIME (years)	BASE (NaOH) ADDITION (gal/30 day)	ACID (H_2SO_4) ADDITION (gal/30 day)	COAGULANT ($FeCl_3$) ADDITION (lb/30 day)	SLUDGE PRODUCED (gal/30 day)	SLUDGE PRODUCED (gal/yr)	SIZE OF TREATMENT PLANT (sq ft)	NO. 8-ft WET WELLS (no.)	RATE OF AIR THROUGH CARBON (ft^3/min)	INITIAL CARBON USAGE (lb/day)
Alternative 4B	100	9	825	425	20	20	220	3,200	4	1000	30
	1 extraction well installed to depth of 80 ft bgs, pumping at 40 gpm. 3 extraction wells each installed to a depth of 110 ft bgs, each pumping at 20 gpm. 20 year total alternative timeframe.										
Alternative 5B	100	12	825	425	20	20	220	3,200	4	1000	30
	1 extraction well installed to depth of 80 ft bgs, pumping at 40 gpm. 3 extraction wells each installed to a depth of 150 ft bgs, each pumping at 20 gpm. 20 year total alternative timeframe.										
Alternative 6B	260	7	2100	1075	40	48	560	4,000	7	2600	70
	1 extraction well installed to depth of 80 ft bgs, pumping at 40 gpm. 11 extraction wells each installed to a depth of 110 ft bgs, each pumping at 20 gpm. 20 year total alternative timeframe.										
Alternative 7B	280	10	2250	1150	45	50	600	4,000	8	2800	75
	1 extraction well installed to depth of 80 ft bgs, pumping at 40 gpm. 12 extraction wells each installed to a depth of 150 ft bgs, each pumping at 20 gpm. 20 year total alternative timeframe.										

(i.e., ex-situ) at one centralized treatment plant location. Justifications for utilizing a centralized treatment system for the groundwater extraction/air stripping (i.e., "pump and treat") alternatives presented in this FS are included in Appendix L. Treatment of the groundwater via air stripping will typically generate an air emission, which will also require treatment to remove vapor phase contaminants. Active source removal and groundwater remediation is in-place or planned at 13 source sites within the NCIA, as previously described.

The objective of groundwater extraction is to draw contaminated groundwater into the capture zone of one or more extraction wells. The flow rate of the extraction well(s) is increased until the capture zone(s) is believed to exceed the contaminated area of concern. The extraction well should ideally be located sufficiently downgradient of the highest contaminated area in the plume so that the majority of the contaminated groundwater will naturally flow into the capture zone. Alternative 4B includes extraction well patterns designed to reduce the VOC concentrations in the off-site groundwater.

When simulating this groundwater extraction and treatment option, the number of wells, pumping rates, and well locations have been optimized by determining which combination would effectively capture the highest percentage of the contaminated groundwater of concern. These analyses were based on data collected for the RI. Prior to final design, aquifer pump tests (i.e., one per plume assumed for this FS) and a treatability/pilot study should be completed to determine more accurate hydraulic conductivity values and other aquifer characteristics that will aid in planning the remedial design and verifying assumptions made regarding number of wells, well spacing, capture zone, flow rates, treatment equipment, and the times required to remediate.

For this FS, Alternative 4B includes the treatment of the contaminated groundwater to a depth of 125 ft bgs via extraction wells. Alternative 4B addresses "hot-spot" areas within the off-site contaminant plumes and assumes that natural attenuation will remediate a portion of the off-site groundwater over time. Table 11-7 summarizes the system components of the groundwater extraction/air stripping system alternatives developed for this FS.

11.3.5.1 ***Extraction Wells.*** Alternative 4B includes the installation of four extraction wells within the contaminant plume. Three 110-ft extraction wells (each 6-in. in

TABLE 11-6

ALTERNATIVE 4A
IN-WELL VAPOR STRIPPING
MONITORING PROGRAM SUMMARY [1]
NCIA Off-Site Groundwater

WELL[2]	Plume Location	DEPTH[3]	SAMPLING SCHEDULE[4] YEARS 1-2	SAMPLING SCHEDULE[5] YEARS 3-20
N-10477	West	57 ft (shallow)	X	X
N-10478	West	121 ft (intermediate)	X	X
N-11851	West	65 ft (shallow)	X	X
NRMW-4	West	70 ft (intermediate)	X	X
N-11848	West	60 ft (shallow)	X	X
N-11860	Central	60 ft (shallow)	X	X
N-11862	Central	60 ft (shallow)	X	X
N-10476	Central	130 ft (deep)	X	X
N-11861	Central	60 ft (shallow)	X	X
EW-1B	Central/East	164 ft (deep)	X	X
EW-1C	Central/East	516 ft (deep)	X	X
EW-2B	Central/East	142 ft (deep)	X	X
EW-2C	Central/East	514 ft (deep)	X	X
NRMW-1	Central/East	70 ft (intermediate)	X	X
N-9939	Central/East	74 ft (intermediate)	X	X
N-10329	East	57 ft (shallow)	X	X
6 proposed new well couplets[6]		**intermediate/deep**	X	X
		TOTAL:	**28**	**28**

X - Sampling is recommended.
1 - This is a preliminary monitoring program developed for cost estimation purposes; the final monitoring program will be established during the remedial design phase; depending on the sample results, the schedule may be modified.
2 - Well locations are depicted on Figures 3-4, 3-5, and 3-6 of the RI report.
3 - Shallow groundwater exists at depths between the water table and 64-ft; intermediate groundwater exists from approximately 65-124 ft bgs. deep groundwater exists at depths of 125 ft bgs or greater.
4 - All samples will be analyzed for VOCs quarterly.
5 - All samples will be analyzed for VOCs annually.
6 - For costing purposes, it is assumed that 6 new monitoring well locations will be established at locations downgradient and sidegradient of existing off-site plumes to monitor future VOC migration. It is assumed that monitoring wells will be installed at intermediate and deep depths as follows:
A total of 3 intermediate wells will be installed to 70 ft bgs; the remaining 3 intermediate wells are to be installed to a depth of 100 ft bgs.
A total of 3 deep wells will be installed to 200 ft bgs, the 3 remaining deep wells are to be installed to a depth of 250 ft bgs.

layout as described for long-term monitoring in Alternative 2). The results of these analyses will be used to determine whether remedial action objectives are being satisfied, and whether changes in system design, configuration, and operation are required. In Alternative 4A, groundwater monitoring is assumed to be conducted quarterly for the first two years after remediation system startup and annually for years 3-20 (i.e., to cover life of remedial system and thirteen additional years to evaluate natural attenuation). Table 11-6 itemizes the groundwater monitoring schedule for Alternative 4A.

The continued need for monitoring can be re-evaluated and possibly discontinued at any time during the project timeframes. For instance, if groundwater contaminant levels remain below the site remedial action objectives for two or three consecutive sampling events, the monitoring program may be considered for discontinuation. If contaminant levels continue to exceed the remedial action objectives at the end of the 20-yr period, the monitoring program should be extended and active remediation may be re-established and/or other remedial actions may be taken.

Inspection of the GAC vapor treatment systems and monitoring of any off-gas emissions will also occur as part of the overall system monitoring. It is assumed that samples of emissions will occur every two months for the first year of system operation, and semiannually after that for the duration of the active remediation timeframe. As with the groundwater monitoring, the continued need for air emissions monitoring will be re-evaluated during the course of the project, and may be reduced or considered for discontinuation after system start-up.

Alternative 4A also includes the operation and maintenance, including replacement of equipment as needed, of the VOC treatment processes that are currently in-place at the Bowling Green Water District (refer to Alternative 1).

11.3.5 Alternative 4B: Remediation of Upper Portion of Aquifer (to 125 ft bgs) with Groundwater Extraction / Centralized Air Stripping and Vapor Treatment / Effluent Re-Injection

Alternative 4B has been developed to evaluate the feasibility of using a groundwater extraction system to capture the off-site groundwater contamination in the upper portion (i.e., at depths from the water table to 125 ft bgs) of the aquifer and treat it at the surface is maintained within satisfactory limits. Any condensate that is created in the system will be collected at the well heads and periodically disposed of at an approved off-site facility.

A preliminary review of the VOC constituents and respective vapor phase concentrations anticipated at each well head for the Alternative 4A scenario indicates that an emission stack will not be required. However, the ultimate configuration of the localized vapor recovery/treatment systems, including GAC usage rates over time, should be based on the final design and results from the pilot studies. Air monitoring and inspection of the vapor treatment systems after startup may also assist in determining system requirements. For cost estimating purposes, GAC was the assumed vapor phase treatment option for the in-well vapor stripping Alternative 4A. However, other vapor phase treatment options (i.e., catalytic oxidation) may be evaluated during the final design and pilot study.

11.3.4.3 ***Waste Disposal.*** Minimal trenching is required for the Alternative 4A scenario, as control of the stripper wells and vapor phase treatment occurs in subsurface vaults placed near each of the treatment wells. It is estimated that approximately 210 yd^3 of uncontaminated, nonhazardous soil will require off-site disposal from the installation of the four stripping wells and treatment vaults in Alternative 4A. All streets and areas disturbed by installation of the remediation system will be restored to original conditions.

It is conservatively estimated that approximately 70 gallons per month of condensate will accumulate under Alternative 4A. Condensate will be periodically collected and disposed of at an approved off-site facility. Analytical sampling of the condensate and any other materials generated during remedial activities will be conducted to characterize the wastes and identify disposal options.

Table 11-5 summarizes the system components of the in-well vapor stripping alternatives developed for this FS.

11.3.4.4 ***System Performance Monitoring.*** To confirm that the in-well vapor stripping system described above for Alternative 4A and natural attenuation are achieving remedial objectives, periodic groundwater sampling will be conducted. For cost estimating purposes, it was assumed that groundwater samples will be collected from 16 existing monitoring wells in the off-site area and analyzed for VOCs. In addition, it is assumed that six new well couplets will be installed at intermediate and deep depths (i.e., same in-well vapor stripping pilot tests (i.e., one per off-site contaminant plume) will be conducted under Alternative 4A.

For cost estimating purposes, it is assumed that the in-well vapor stripping system will run for seven years under Alternative 4A (based on discussion with vendors and a review of case studies). The actual timeframe may differ from seven years; better estimates of cleanup time can be made based on the pilot tests. The seven year timeframe for active remediation accounts for the fact that stripper wells are placed only in "hot spot" areas. The four stripper wells may actually need to run longer than estimated since contamination from outside the "hot spot" areas may be drawn to the wells during the course of remediation. Many parameters used in deriving this estimate can vary widely, which would impact the remediation time. Results of pilot tests should be used to better estimate the Alternative 4A timeframe.

11.3.4.2 ***Vapor Phase Treatment.*** For Alternatives 4A, vapors from the in-well vapor stripping processes will be collected from each stripping well and transferred with a vacuum extraction blower to a GAC treatment system within each vault. The vapors containing VOCs are passed through the GAC medium, adsorbed, and then vented to the atmosphere. GAC was selected as the optimal vapor phase treatment option for Alternative 4A based on anticipated flow rates and contaminant concentrations.

In Alternative 4A, the vapor phase flow rates to the local GAC treatment system differ for each type of stripper well (i.e., 80-ft and 125-ft treatment wells). The vapor phase flow rate (assuming a 75:1 air-to-water ratio) was calculated to be 700 scfm. The initial carbon usage rate was estimated to be 35 lb/day. A summary of the in-well vapor stripping system components is included in Table 11-5. For the in-well vapor stripping alternatives, it is assumed that as VOC concentrations in the groundwater and vapor streams are reduced over time, the carbon usage rates will also decrease. When GAC is spent (i.e., saturated with VOCs), it is transported off-site for regeneration and replaced with fresh material.

High relative humidity of the treated vapor (i.e., above about 50%) reduces the adsorption efficiency of the GAC. Thus, vacuum extraction blowers in Alternative 4A should be specified so that sufficient heat is imparted to the vapor stream and the relative humidity moisture separators and condensate storage containers; and system control equipment (i.e., valves, meters, electronics, gauges, chemical delivery systems [if required]). Subsurface treatment vaults will be constructed adjacent to each of the in-well vapor stripping wells. The vaults will house all treatment equipment associated with this alternative, and will be constructed to be "low profile" as to blend-in with the surrounding residential/institutional properties. Significant quantities of piping for air injection and vapor extraction are not needed in Alternative 4A since all treatment is conducted at each well head. Justifications for utilizing localized treatment systems for the in-well vapor stripping alternatives presented in this FS are included in Appendix L.

Operation and maintenance costs include electricity to power the remediation system; periodic repair and replacement of system parts/components; routine operator inspection of the system; and system monitoring. Based on data from recent groundwater sampling events in the off-site area and discussions with a vender of the in-well vapor stripping technology, it was determined that an iron control system would likely not be needed for the in-well vapor stripping alternatives. Rather, any iron/inorganic precipitation can be addressed with routine cleaning of UVB well components as part of the system operation and maintenance program. System inspection, maintenance, and monitoring activities consist of assessments of the in-well vapor stripping system, cleaning and maintaining the components, and collection of real-time air measurements, as necessary. For Alternative 4A, it is assumed that a part-time operator will be needed to operate, supervise, and monitor the in-well vapor stripping process and localized treatment vaults.

Prior to final design of Alternative 4A, pilot-scale treatability studies should be performed to determine the off-site groundwater remediation timeframes and system specifications of the in-well vapor stripping systems. Pilot scale tests can also determine optimal system configurations and design parameters, such as number/location of wells, operating pressures, and flow rates to remove contaminants from the groundwater. The results of a pilot study can also be used to evaluate the airflow distribution and vapor phase treatment approaches. In addition, potential impacts from natural iron and pH in the subsurface can be better evaluated. The results of the pilot tests will also be used to better estimate the power requirements of the systems. Any potential effects from in-well vapor stripping on the Bowling Green supply wells or other remediation systems (i.e., within the NCIA) can also be evaluated. For this FS, it was assumed that a total of three

Table 11-5

IN-WELL VAPOR STRIPPING SUMMARY

NCIA Off-Site Groundwater

	NO. 125 or 200 ft Treatment Wells 10 gpm 100 scfm	NO. Containment Treatment Wells 10 gpm 100 scfm	NO. 80 or 140 ft Treatment Wells 40 gpm 400 scfm	TOTAL FLOW (gpm)	ACTIVE REMEDIATION TIME (years)	TOTAL ALTERNATIVE TIMEFRAME (years)	TOTAL CONDENSATE (gal/year)	RATE OF AIR THROUGH CARBON (ft^3/min)	INITIAL CARBON USAGE (lb/day)
Alternative 4A	3 Well Depth = 125 ft bgs H = 55 ft ROI = 250 ft	0 NA NA NA	1 Well Depth = 80 ft bgs H = 20 ft ROI = 120 ft	70	7	20	860	700	35
Alternative 5A	3 Well Depth = 200 ft bgs H = 100 ft ROI = 325 ft	0 NA NA NA	3 Well Depth = 140 ft bgs H = 50 ft ROI = 175 ft	150	9	20	1820	1500	60
Alternative 6A	3 Well Depth = 125 ft bgs H = 55 ft ROI = 250 ft	5 Well Depth = 150 ft bgs H = 80 ft ROI = 315 ft	1 Well Depth = 80 ft bgs H = 20 ft ROI = 120 ft	120	5	20	1460	1200	55
Alternative 7A	4 Well Depth = 200 ft bgs H = 100 ft ROI = 325 ft	5 Well Depth = 225 ft bgs H = 150 ft ROI = 510 ft	4 Well Depth = 140 ft bgs H = 50 ft ROI = 175 ft	250	7	20	3040	2500	105

Notes: - H denotes approximate vertical distance between well screens.
- ROI denotes anticipated radius of influence for stripper wells.

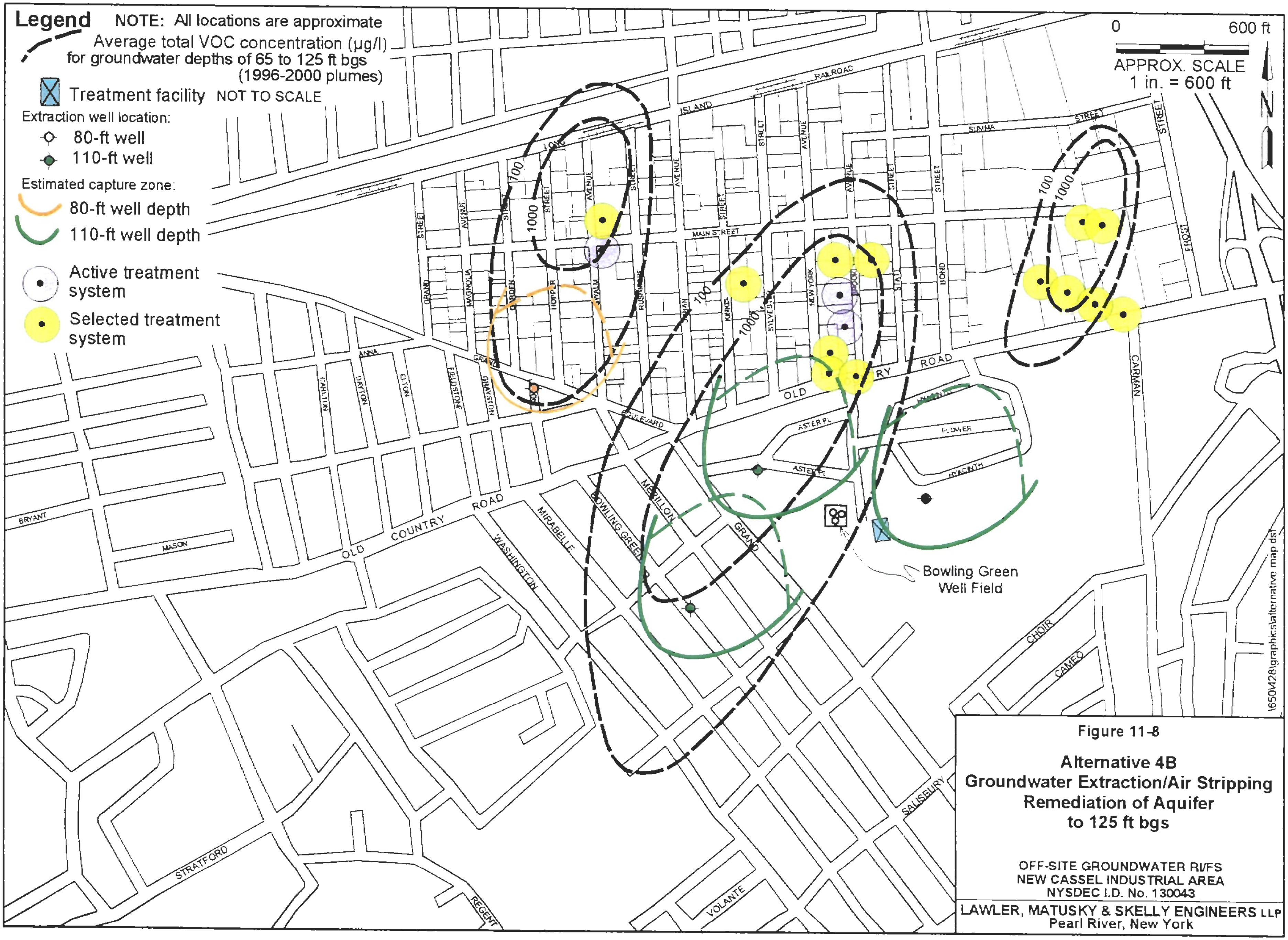

Figure 11-8

Alternative 4B
Groundwater Extraction/Air Stripping
Remediation of Aquifer
to 125 ft bgs

OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
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appropriate. Treatment for Alternative 4B will occur in a central location within the NCIA off-site area, as described above. The exact location and configuration of the central treatment building should be confirmed during the design phase.

In Alternative 4B, after the pumped groundwater has been metered inside of the treatment facility, it undergoes various levels of treatment, as shown in Figure 11-9. The contaminated groundwater first enters an equalization tank (with a mixer) to equalize the flows from the extraction wells. The water will then flow via gravity into a pH adjustment/reaction tank. With the addition of a base compound (e.g., sodium hydroxide), the pH will be raised to about 8 to 10, and a coagulant will be added into the reaction tank to help flocculate and precipitate any soluble inorganic constituents. A mixer will ensure that the base and the coagulant become completely mixed before passing (via gravity) into the settling tank/clarifier unit. In the settling tank, a sludge will be produced as inorganic compounds (such as soil particles) settle to the bottom of the tank. The sludge will be dewatered to form a sludge cake, which will be disposed of off-site. It is assumed in the cost estimate that this sludge cake will be disposed of as nonhazardous waste; this assumption should be verified in the final design phase with TCLP waste characterization analyses. The supernatant from the dewatering process will be recycled back into the equalization tank. Anticipated chemical use and sludge production rates for all of the groundwater extraction/air stripper alternatives are summarized in Table 11-7.

The contaminated groundwater that passes through the settling tank will then be pumped into a media filter to remove solids. An acidic compound (e.g., sulfuric acid) will be added to lower the pH to about 6 to 7 before the water is fed into a low profile tray air stripper. The low profile stripper is better suited than an air stripping tower for this project due to the proximity of residential and institutional properties. GAC was selected as the optimal vapor phase treatment option for Alternative 4B based on anticipated flow rates and contaminant concentrations. The vapor emitted from the air stripper will undergo treatment via GAC to remove the volatile constituents that have been stripped out of the groundwater. A vapor phase flow rate of 1000 scfm was estimated for Alternative 4B. Following vapor phase GAC treatment, the air emission will be vented to the atmosphere. An initial carbon usage rate of 30 lb/day was estimated for Alternative 4B. Vapor flow rates and initial carbon usage rates for the groundwater extraction/air stripping alternatives are listed in Table 11-7.

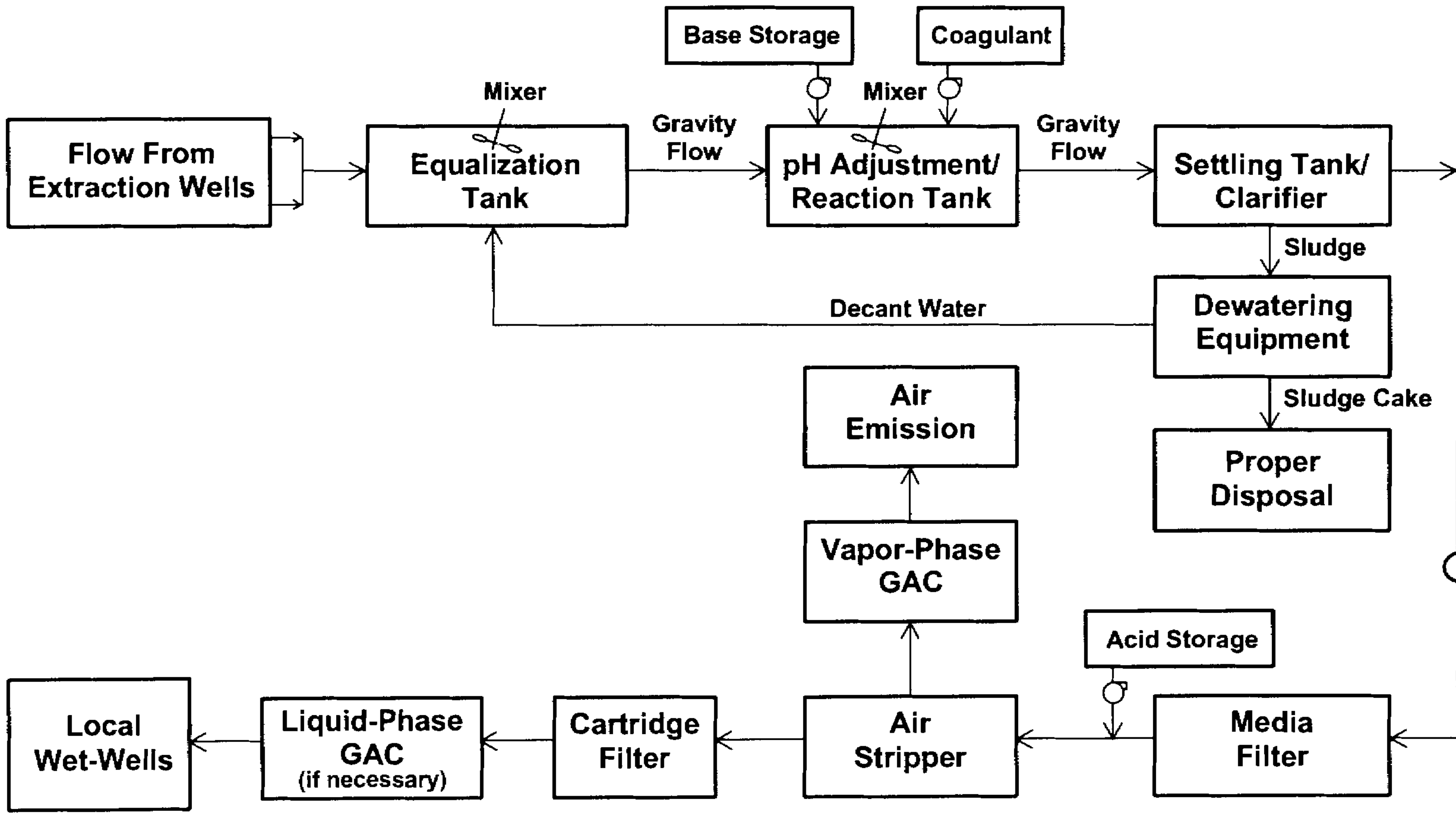

Figure 11-9
Schematic of
Groundwater Treatment Operations
Groundwater Extraction/Air Stripping
OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
NYSDEC I.D. No. 130043
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A preliminary review of the VOC constituents and respective vapor phase concentrations indicates that an emission stack will probably not be required. However, the ultimate configuration of the entire vapor recovery/treatment system, including GAC usage rates over time, should be based on the final design and results from the pilot study. Air monitoring and inspection of the vapor treatment system after startup may also assist in determining system requirements. For cost estimating purposes, GAC was the assumed vapor phase treatment option for Alternative 4B. However, other vapor phase treatment options (i.e., catalytic oxidation) may be evaluated during the final design and pilot study. In addition, results from the pilot study should be used during the detailed design of the groundwater treatment facility to confirm chemical dosage rates and process specifications, as well as to optimize the contact times in the tanks. Potential impacts from iron and natural pH in the subsurface can also be better assessed.

The liquid effluent leaving the air stripper will be passed through a cartridge filter to remove any remaining solids before being discharged into nearby wet wells for re-injection to the subsurface. The wet wells are assumed to be located next to the central treatment building, within Nassau County Basin 51 (a local stormwater retention basin). As shown in Table 11-7, Alternative 4B will have four 8-ft diameter wet wells with approximate depths of 15 ft bgs. The wet wells will be operated in parallel to handle overflow and maintenance periods. Re-injection of treated water into the subsurface will require that all relevant discharge standards are achieved. In addition, local or state permits may be required. The treatability/pilot study will help to evaluate the ability of the treatment processes to meet discharge requirements. A pilot study can also help determine reinjection schedules and potential impacts of reinjection on the Bowling Green supply wells or other remediation systems (i.e., within the NCIA). If discharge limitations are not satisfied, polishing with carbon adsorption may be necessary. The treated effluent will be periodically monitored to ensure that discharge limits are met (sampling frequencies are described in the next section).

Due to the need for a treatment facility at the proposed location, an appropriate building would need to be constructed to house the treatment equipment (i.e., the treatment facility and associated units and piping should be low profile as to blend-in with the surroundings). For Alternative 4B, it is suspected that a half-time operator will be needed to operate, supervise, and monitor the extraction wells and the treatment plant processes.

It is estimated that approximately 15 yd^3 of nonhazardous soil will require off-site disposal from the installation of the four extraction wells in Alternative 4B. In addition, approximately 14,800 ft^2 of asphalt will also be excavated and require off-site disposal under Alternative 4B. All streets and areas disturbed by trenching and installation of the remediation systems will be restored to original conditions. It is estimated that approximately 3700 l.f. of trenching are required under Alternative 4B.

Operation and maintenance associated with the treatment system costs include electricity to power the remediation system; periodic repair and replacement of system parts/components; routine operator inspection of the system; and system monitoring. System inspection, maintenance, and monitoring activities consist of assessments of the system, cleaning and maintaining the components, and collection of real-time air measurements, as necessary.

11.3.5.3 ***System Performance Monitoring.*** For the purposes of this FS, it is assumed that the extraction and treatment system for Alternatives 4B will operate for nine years. This estimate was based on the time it would take for the furthest contaminant with the slowest velocity in the groundwater of concern to be captured by the groundwater extraction system (approximately seven years). The controlling retardation factor, which affects contaminant transport velocity, was found to be that of PCE. An average hydraulic conductivity of 70 ft/day was used in the calculation. Two additional years were added to the Alternative 4B active remediation timeframe, for a total of nine years, to account for the fact that extraction wells are placed only in "hot spot" areas. The four extraction wells may actually need to run longer than calculated since contamination from outside the "hot spot" areas may be drawn to the wells during the course of remediation. Many parameters used in deriving this estimate can vary widely, which would impact the remediation time. Results of pilot tests should be used to better estimate the Alternative 4B timeframe.

The long-term monitoring program included in this alternative is intended to assess the effectiveness of groundwater extraction/treatment and natural attenuation on the contaminant levels in the aquifer over time. Monitoring will consist of system performance monitoring and effluent quality monitoring. For Alternative 4B, during the first three months that the treatment plant is in operation, VOC samples will be collected from the equalization tank and the effluent pipe once per week to evaluate the efficiency and effectiveness of the treatment plant. The effluent sample analysis will be used to demonstrate that all discharge requirements are being met. For the remainder of the active remediation life of the alternative, VOC sampling at each of the influent pipes and the single effluent pipe at the treatment plant will be collected once per month. Samples will be analyzed for conventional parameters (e.g., pH, solids, and alkalinity) as well as VOC content. As reference, Table 11-8 lists the effluent limitations for the VOCs of concern.

In addition, periodic monitoring well sampling will be conducted to ensure that the pump and treat system and natural attenuation are remediating the off-site groundwater contaminant plumes. For cost estimating purposes, it was assumed that groundwater samples will be collected from 16 existing monitoring wells in the off-site area and analyzed for VOCs. In addition, it is assumed that six new well couplets will be installed at intermediate and deep depths (i.e., same layout as described for long-term monitoring in Alternative 2). The results of these analyses will be used to determine whether remedial action objectives are being satisfied, and whether changes in system design, configuration, and operation are required. In Alternative 4B, groundwater monitoring is assumed to be conducted quarterly for two years after remediation system startup and annually for year 3-20 to cover the remainder of the estimated life of the active remediation and an additional eleven years to evaluate natural attenuation. Table 11-9 itemizes the groundwater monitoring schedule for Alternative 4B.

The continued need for monitoring can be re-evaluated and possibly discontinued at any time during the project timeframes. For instance, if groundwater contaminant levels remain below the site remedial action objectives for two or three consecutive sampling events, the monitoring program may be considered for discontinuation. If contaminant levels continue to exceed the remedial action objectives at the end of the 20-yr period, the monitoring program should be extended and active remediation may be re-established and/or other remedial actions may be taken.

Inspection of the GAC vapor treatment system and monitoring of any off-gas emissions will also occur as part of the overall system monitoring. It is assumed that samples of emissions will occur every two months for the first year of system operation, and semiannually after that for the duration of the active remediation timeframe. As with the

TABLE 11-8

EFFLUENT LIMITATIONS FOR COCs

NCIA Off-Site Groundwater

Chemical Constituent	Effluent Limitation [1] (µg/l)
1,1-Dichloroethane	5
1,1-Dichloroethene	5
1,2-Dichloroethene (total)	5
1,2-Dichloroethane	0.6
Tetrachloroethene	5
Trichloroethene	5
Vinyl Chloride	2
1,1,1-Trichloroethane	5
Iron and Manganese (combined)	1,000

1 - Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations, Table 5 (NYSDEC 1998).

TABLE 11-9

ALTERNATIVE 4B
GROUNDWATER EXTRACTION / AIRSTRIPPING
MONITORING PROGRAM SUMMARY [1]
NCIA Off-Site Groundwater

WELL[2]	Plume Location	DEPTH [3]	SAMPLING SCHEDULE [4] YEARS 1-2	SAMPLING SCHEDULE [5] YEARS 3-20
N-10477	West	57 ft (shallow)	X	X
N-10478	West	121 ft (intermediate)	X	X
N-11851	West	65 ft (shallow)	X	X
NRMW-4	West	70 ft (intermediate)	X	X
N-11848	West	60 ft (shallow)	X	X
N-11860	Central	60 ft (shallow)	X	X
N-11862	Central	60 ft (shallow)	X	X
N-10476	Central	130 ft (deep)	X	X
N-11861	Central	60 ft (shallow)	X	X
EW-1B	Central/East	164 ft (deep)	X	X
EW-1C	Central/East	516 ft (deep)	X	X
EW-2B	Central/East	142 ft (deep)	X	X
EW-2C	Central/East	514 ft (deep)	X	X
NRMW-1	Central/East	70 ft (intermediate)	X	X
N-9939	Central/East	74 ft (intermediate)	X	X
N-10329	East	57 ft (shallow)	X	X
6 proposed new well couplets[6]		**intermediate/deep**	X	X
		TOTAL:	**28**	**28**

X - Sampling is recommended.
1 - This is a preliminary monitoring program developed for cost estimation purposes; the final monitoring program will be established during the remedial design phase; depending on the sample results, the schedule may be modified.
2 - Well locations are depicted on Figures 3-4, 3-5, and 3-6 of the RI report.
3 - Shallow groundwater exists at depths between the water table and 64-ft; intermediate groundwater exists from approximately 65-124 ft bgs. deep groundwater exists at depths of 125 ft bgs or greater.
4 - All samples will be analyzed for VOCs quarterly.
5 - All samples will be analyzed for VOCs annually.
6 - For costing purposes, it is assumed that 6 new monitoring well locations will be established at locations downgradient and sidegradient of existing off-site plumes to monitor future VOC migration. It is assumed that monitoring wells will be installed at intermediate and deep depths as follows:
A total of 3 intermediate wells will be installed to 70 ft bgs, the remaining 3 intermediate wells are to be installed to a depth of 100 ft bgs.
A total of 3 deep wells will be installed to 200 ft bgs; the 3 remaining deep wells are to be installed to a depth of 250 ft bgs.

groundwater monitoring, the continued need for air emissions monitoring will be re-evaluated during the course of the project, and may be reduced or considered for discontinuation after system start-up.

Alternative 4B also includes the operation and maintenance, including replacement of equipment as needed, of the VOC treatment processes that are currently in-place at the Bowling Green Water District (refer to Alternative 1).

11.3.6 Alternative 5A: Remediation of Upper and Deep Portions of Aquifer (to 200 ft bgs) with In-Well Vapor Stripping / Localized Vapor Treatment

Alternative 5A is similar to Alternative 4A presented above but utilizes in-well vapor stripping to address contaminated groundwater in the upper and deep portions of the aquifer. It addresses "hot-spot" areas within the off-site contaminant plumes and assumes that natural attenuation will remediate a portion of the off-site groundwater over time. As discussed above, active source removal and groundwater remediation is in-place or planned at 13 source sites within the NCIA. Figure 11-10 shows approximate locations of the stripping wells for Alternative 5A. Figure 11-11 shows total VOC contaminant plumes (averaged from depths of 65 – 200 ft bgs) from years 1996-2000. Figures 11-12 displays treatment well radii of influence and portions of the off-site plumes addressed in Alternative 5A.

Alternative 5A includes the treatment of the contaminated off-site groundwater via six in-well vapor stripping wells. Alternative 5A includes the installation of three 140-ft and three 200-ft treatment wells. Table 11-5 summarizes the system components and operation parameters for Alternative 5A. As for the scenarios presented for the other in-well vapor stripping alternatives, pilot studies and field measurements in the design phase of work will more accurately determine the construction details and placement of each of the in-well vapor stripping wells in Alternative 5A, along with the specific groundwater circulation/treatment patterns expected to result.

Based on the treatment technology and aquifer characteristics in the off-site area, the estimated groundwater flow rate in each of the 140-ft wells is 40 gpm and the flow rate in the 200-ft wells is 10 gpm. According to venders of the in-well vapor stripping technology, the following radii of influence can be achieved for each type of stripping

Figure 11-10

Alternative 5A
In-well Vapor Stripping
Remediation of Upper and Deep Portions of Aquifer (to 200 ft BGS)

OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
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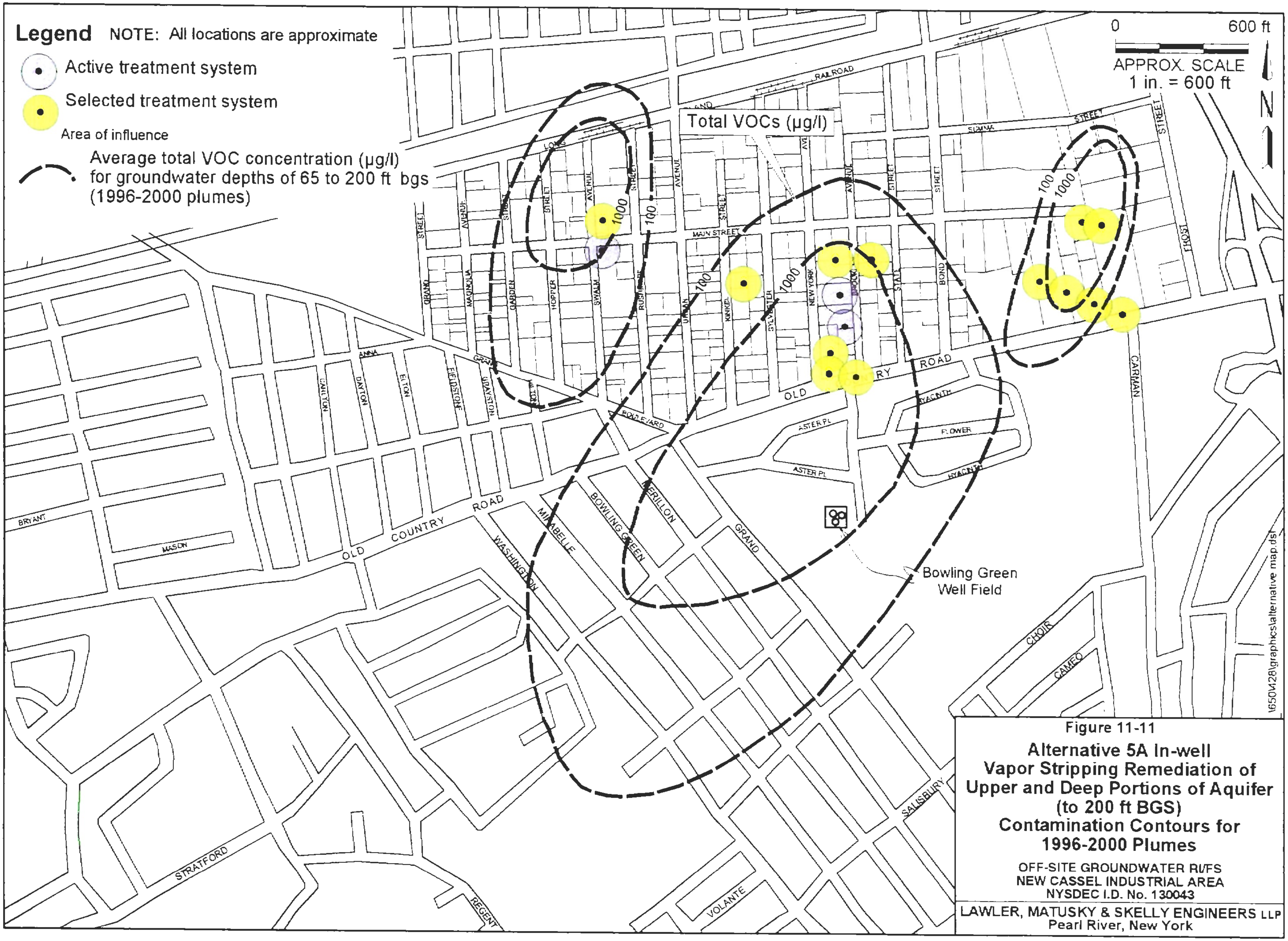

Figure 11-11

Alternative 5A In-well Vapor Stripping Remediation of Upper and Deep Portions of Aquifer (to 200 ft BGS) Contamination Contours for 1996-2000 Plumes

OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
NYSDEC I.D. No. 130043

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Figure 11-12
Alternative 5A In-well Vapor Stripping Remediation of Upper and Deep Portions of Aquifer (to 200 ft BGS) Treatment Well Placement and Contamination Contours for 1996-2000 Plumes

OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
NYSDEC I.D. No. 130043

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well in Alternative 5A: 140-ft well: 175 ft; and 200-ft well: 325 ft (refer to Figure 11-12).

Prior to the final design of Alternative 5A, pilot-scale treatability studies should be performed to determine the off-site groundwater remediation timeframe and specifications of the in-well vapor stripping system. A pilot scale test can also determine optimal system configurations and design parameters, such as number/location of wells, operating pressures, and flow rates to remove contaminants from the groundwater. The results of a pilot study can also be used to evaluate the airflow distribution and vapor phase treatment approaches. In addition, potential impacts from natural iron and pH in the subsurface can be better evaluated. The results of the pilot tests will also be used to better estimate the power requirements of the system. Any potential effects from in-well vapor stripping on the Bowling Green supply wells or other remediation systems (i.e., within the NCIA) can also be evaluated. For this FS, it was assumed that a total of three in-well vapor stripping pilot tests (i.e., one per off-site contaminant plume) will be conducted under Alternative 5A. It is also assumed that a half-time system operator will be need for this alternative.

For cost estimating purposes, it is assumed that the in-well vapor stripping system will run for nine years under Alternative 5A (based on discussion with vendors and a review of case studies). This active remediation timeframe accounts for the fact that stripper wells are placed only in "hot spot" areas. The six stripper wells may actually need to run longer than estimated since contamination from outside the "hot spot" areas may be drawn to the wells during the course of remediation. Many parameters used in deriving this estimate can vary widely, which would impact the remediation time. Results of pilot tests should be used to better estimate the Alternative 5A timeframe.

11.3.6.1 ***Vapor Phase Treatment.*** For Alternative 5A, vapors from the in-well vapor stripping processes will be collected from each stripping well and transferred with a vacuum extraction blower to a GAC treatment system within each local vault. The vapors containing VOCs are passed through the GAC medium, adsorbed, and then vented to the atmosphere. GAC was selected as the optimal vapor phase treatment option for Alternative 5A based on anticipated flow rates and contaminant concentrations.

In Alternative 5A, the vapor phase flow rates to the local GAC treatment systems differ for each type of stripper well. The vapor phase flow rates (scfm, assuming 75:1 air-to-water ratio) and initial carbon usage rates are summarized for Alternative 5A in Table 11-5. As for the other in-well vapor stripping alternatives, it was assumed that as VOC concentrations in the groundwater and vapor streams are reduced over time, the carbon usage rates will also decrease. When GAC is spent (i.e., saturated with VOCs), it is transported off-site for regeneration and replaced with fresh material.

High relative humidity of the treated vapor (i.e., above about 50%) reduces the adsorption efficiency of the GAC. Thus, vacuum extraction blowers in Alternative 5A should be specified so that sufficient heat is imparted to the vapor stream and the relative humidity is maintained within satisfactory limits.

A preliminary review of the VOC constituents and respective vapor phase concentrations anticipated at each well head for the Alternative 5A scenario indicates that an emission stack will not be required. However, the ultimate configurations of the localized vapor recovery/treatment systems, including GAC usage rates over time, should be based on the final design and results from the pilot study. Air monitoring and inspection of the vapor treatment systems after startup may also determine system requirements. For cost estimating purposes, GAC was the assumed vapor phase treatment option for the in-well vapor stripping Alternative 5A. However, other vapor phase treatment options (i.e., catalytic oxidation) may be evaluated during the final design and pilot study.

11.3.6.2 ***Waste Disposal.*** Minimal trenching is required for the Alternative 5A scenario, as control of the stripper wells and vapor phase treatment occur in subsurface vaults placed near each of the treatment wells. It is estimated that approximately 310 yd^3 of nonhazardous soil will require off-site disposal from the installation of the six stripping wells and treatment vaults in Alternative 5A. All streets and areas disturbed by installation of the remediation system will be restored to original conditions.

Conservative estimates for condensate accumulation were made for Alternative 5A (refer to Table 11-5). Condensate will be periodically collected and disposed of at an approved off-site facility. Analytical sampling of the condensate and any other materials generated during remedial activities will be conducted to characterize the wastes and identify disposal options.

11.3.6.3 ***System Performance Monitoring.*** To confirm that the in-well vapor stripping system described above for Alternative 5A and natural attenuation are achieving remedial objectives, periodic groundwater sampling will be conducted. For cost estimating purposes, it was assumed that groundwater samples will be collected from 16 existing monitoring wells in the off-site area and analyzed for VOCs. In addition, it is assumed that six new well couplets will be installed at intermediate and deep depths (i.e., same layout as described for long-term monitoring in Alternative 2). The results of these analyses will be used to determine whether remedial action objectives are being satisfied, and whether changes in system design, configuration, and operation are required. In Alternative 5A, groundwater monitoring is assumed to be conducted quarterly for the first two years after remediation system startup and annually for years 3-20 (i.e., to cover life of remedial system and eleven additional years to evaluate natural attenuation). Table 11-10 itemizes the groundwater monitoring schedule for the Alternative 5A scenario.

The continued need for monitoring can be re-evaluated and possibly discontinued at any time during the project timeframe. For instance, if groundwater contaminant levels remain below the remedial action objectives for two or three consecutive sampling events, the monitoring program may be considered for discontinuation. If contaminant levels continue to exceed the remedial action objectives at the end of the 20-yr period, the monitoring program should be extended and active remediation may be re-established and/or other remedial actions may be taken.

Inspection of the GAC vapor treatment system and monitoring of any off-gas emissions will also occur as part of the overall system monitoring. It is assumed that samples of emissions will occur every two months for the first year of system operation, and semiannually after that for the duration of the alternative timeframe. As with the groundwater monitoring, the continued need for air emissions monitoring will be re-evaluated during the course of the project, and may be reduced or considered for discontinuation after system start-up.

Alternative 5A also includes the operation and maintenance, including replacement of equipment as needed, of the VOC treatment processes that are currently in-place at the Bowling Green Water District (refer to Alternative 1).

TABLE 11-10

ALTERNATIVE 5A
IN-WELL VAPOR STRIPPING
MONITORING PROGRAM SUMMARY [1]
NCIA Off-Site Groundwater

WELL[2]	Plume Location	DEPTH[3]	SAMPLING SCHEDULE[4] YEARS 1-2	SAMPLING SCHEDULE[5] YEARS 3-20
N-10477	West	57 ft (shallow)	X	X
N-10478	West	121 ft (intermediate)	X	X
N-11851	West	65 ft (shallow)	X	X
NRMW-4	West	70 ft (intermediate)	X	X
N-11848	West	60 ft (shallow)	X	X
N-11860	Central	60 ft (shallow)	X	X
N-11862	Central	60 ft (shallow)	X	X
N-10476	Central	130 ft (deep)	X	X
N-11861	Central	60 ft (shallow)	X	X
EW-1B	Central/East	164 ft (deep)	X	X
EW-1C	Central/East	516 ft (deep)	X	X
EW-2B	Central/East	142 ft (deep)	X	X
EW-2C	Central/East	514 ft (deep)	X	X
NRMW-1	Central/East	70 ft (intermediate)	X	X
N-9939	Central/East	74 ft (intermediate)	X	X
N-10329	East	57 ft (shallow)	X	X
6 proposed new well couplets[6]		**intermediate/deep**	X	X
		TOTAL:	28	28

X - Sampling is recommended.
1 - This is a preliminary monitoring program developed for cost estimation purposes; the final monitoring program will be established during the remedial design phase; depending on the sample results, the schedule may be modified.
2 - Well locations are depicted on Figures 3-4, 3-5, and 3-6 of the RI report.
3 - Shallow groundwater exists at depths between the water table and 64-ft; intermediate groundwater exists from approximately 65-124 ft bgs deep groundwater exists at depths of 125 ft bgs or greater.
4 - All samples will be analyzed for VOCs quarterly.
5 - All samples will be analyzed for VOCs annually.
6 - For costing purposes, it is assumed that 6 new monitoring well locations will be established at locations downgradient and sidegradient of existing off-site plumes to monitor future VOC migration. It is assumed that monitoring wells will be installed at intermediate and deep depths as follows:
   A total of 3 intermediate wells will be installed to 70 ft bgs; the remaining 3 intermediate wells are to be installed to a depth of 100 ft bgs
   A total of 3 deep wells will be installed to 200 ft bgs; the 3 remaining deep wells are to be installed to a depth of 250 ft bgs.

11.3.7 Alternative 5B: Remediation of Upper and Deep Portions of Aquifer (to 200 ft bgs) with Groundwater Extraction / Centralized Air Stripping and Vapor Treatment / Effluent Re-Injection

Alternative 5B is similar to Alternative 4B presented above but includes treatment of the contaminated groundwater in the upper and deep portions of the aquifer. It addresses "hot-spot" areas within the off-site contaminant plumes and assumes that natural attenuation will remediate a portion of the off-site groundwater over time. As discussed above, active contaminant source removal and groundwater remediation is in-place or planned at 13 source sites within the NCIA. Figure 11-13 shows approximate locations of the extraction wells and the centralized treatment structure for Alternative 5B. On Figure 11-13, average total VOC plumes were derived from contaminant plume maps for groundwater at depths of 65 to 200 ft bgs. As shown, four extraction wells (one 80-ft well and three 150-ft wells) are included under Alternative 5B. Details and construction of the extraction wells used in Alternative 5B are as described in Alternative 4B. As in Alternative 4B, the bottom 20 ft of each extraction well will be screened. It is assumed under Alternative 5B that the 150-ft extraction wells will remove groundwater contamination from depths as great as 200 ft bgs. This assumption, and final extraction well details, should be confirmed during pilot studies and in the design phase of work. The central structure (approximately 3200 sf) will likely be located to the east of the Bowling Green supply wells (same location as central treatment building described for other pump and treat scenarios). The structure size and location shall be confirmed in the final design.

Table 11-7 summarizes the system components for Alternative 5B. As for the scenarios presented for the other pump and treat alternatives, aquifer pump tests and pilot studies (i.e., one per plume) in the design phase of work will more accurately determine the construction details and placement of each of the extraction wells and recharge wet wells in Alternative 5B.

As shown in Table 11-7, the scenario presented under Alternative 5B will utilize four wet wells with approximate depths of 15 ft bgs for re-injection of treated groundwater to the subsurface. The wet wells will be located beside the central treatment building. Re-injection of treated water into the subsurface will require that all relevant discharge

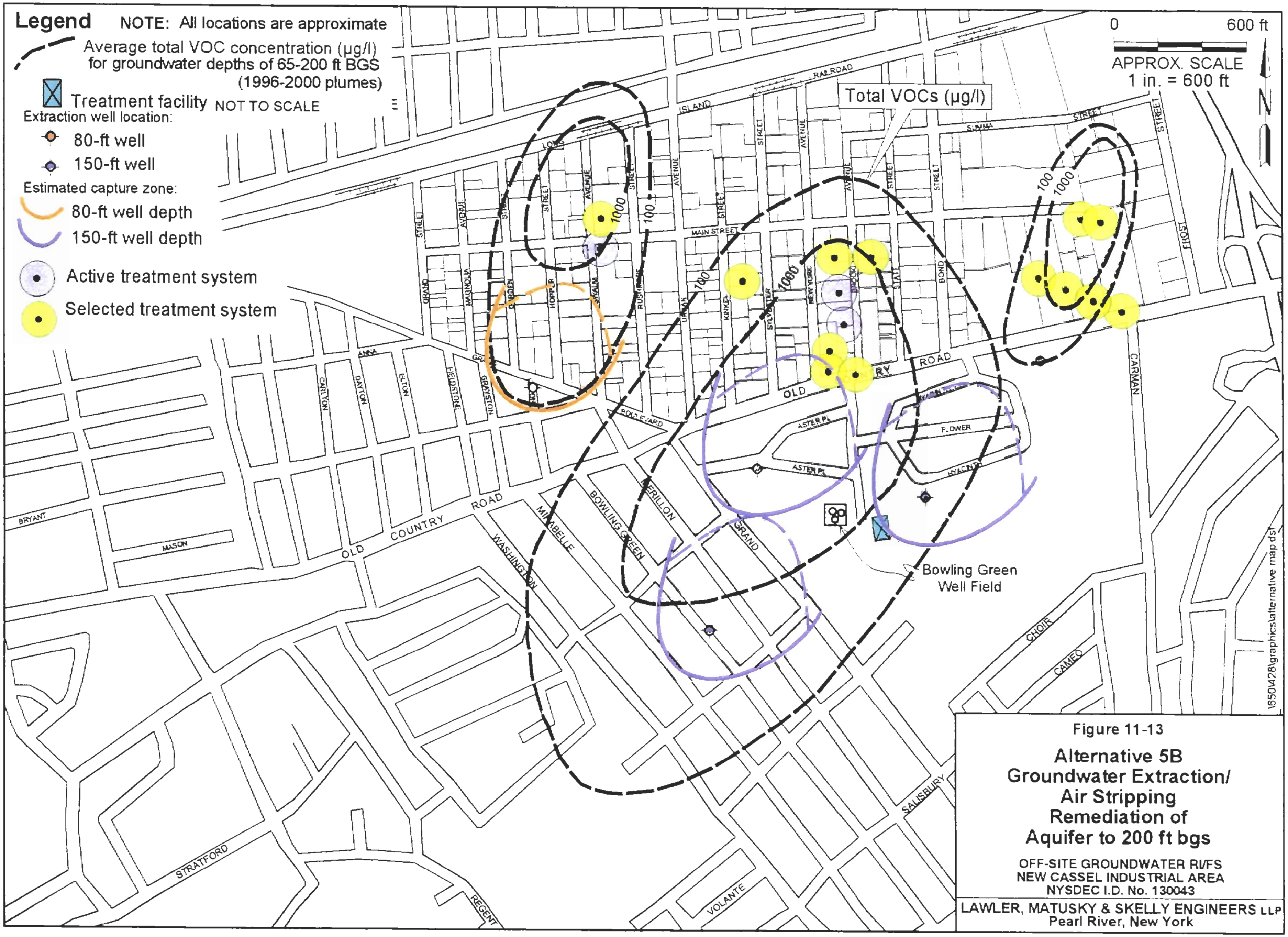

Figure 11-13

Alternative 5B
Groundwater Extraction/ Air Stripping Remediation of Aquifer to 200 ft bgs

OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
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standards are achieved. In addition, local or state permits may be required. The treatability/pilot studies will help to evaluate the ability of the treatment processes to meet discharge requirements near the treatment building. Pilot studies can also help determine reinjection schedules and potential impacts of reinjection on the Bowling Green supply wells or other remediation systems (i.e., within the NCIA). If discharge limitations are not satisfied, polishing via carbon adsorption may be necessary. The treated effluent will be periodically monitored to ensure that discharge limits are met.

It is estimated that approximately 20 yd^3 of nonhazardous soil will require off-site disposal from the installation of the extraction wells in Alternative 5B. In addition, approximately 14,800 ft^2 of asphalt will also be excavated and require off-site disposal under Alternative 5B. All streets and areas disturbed by trenching and installation of the remediation system will be restored to original conditions. It is estimated that approximately 3700 l.f. of trenching are required under Alternative 5B.

For Alternative 5B, it is assumed that a half-time operator will be needed to operate, supervise, and monitor the treatment system. Operation and maintenance items described for the other pump and treat alternatives (i.e., electricity; periodic repair and replacement of system parts/components; routine operator inspection of the system; and system monitoring) also apply to Alternative 5B. System inspection, maintenance, and monitoring activities consist of assessments of the remediation system, cleaning and maintaining the components, and collection of real-time air measurements, as required.

For cost estimating purposes in this FS, an estimated timeframe for active remediation of 12 years was used for Alternative 5B. This 12-year timeframe accounts for the fact that extraction wells are placed only in "hot spot" areas. The four extraction wells may actually need to run longer than estimated since contamination from outside the "hot spot" areas may be drawn to the wells during the course of remediation. Many parameters used in deriving this estimate can vary widely, which would impact the remediation time. Results of pilot tests should be used to better estimate the Alternative 5B timeframe.

11.3.7.1 ***System Performance Monitoring.*** The long-term monitoring program included in this alternative is intended to assess the effectiveness of groundwater extraction and treatment and natural attenuation on the contaminant levels in the aquifer over time. Monitoring will consist of system performance monitoring and effluent quality monitoring. For Alternative 5B, during the first three months that the treatment plant is in operation, VOC samples will be collected from the equalization tank and the effluent pipe once per week to evaluate the efficiency and effectiveness of the treatment plant. The effluent sample analysis will be used to demonstrate that all discharge requirements are being met. For the remainder of the active remediation timeframe, VOC sampling at each of the influent pipes and the single effluent pipe at the treatment plant will be collected once per month. Samples will be analyzed for conventional parameters (e.g., pH, solids, and alkalinity) as well as VOC content. As reference, Table 11-8 lists the effluent limitations (Class GA) for the VOCs of concern.

To confirm that the groundwater extraction/air stripping system described above for Alternative 5B and natural attenuation are achieving remedial objectives, periodic groundwater sampling will be conducted. For cost estimating purposes, it was assumed that groundwater samples will be collected from 16 existing monitoring wells in the off-site area and analyzed for VOCs. In addition, it is assumed that six new well couplets will be installed at intermediate and deep depths (i.e., same layout as described for long-term monitoring in Alternative 2). The results of these analyses will be used to determine whether remedial action objectives are being satisfied, and whether changes in system design, configuration, and operation are required. In Alternative 5B, groundwater monitoring is assumed to be conducted quarterly for two years after remediation system startup and annually for year 3-20 to cover the remainder of the estimated life of the active remediation and an additional eight years to evaluate natural attenuation. Table 11-11 itemizes the groundwater monitoring schedule for the Alternative 5B scenario.

The continued need for groundwater monitoring can be re-evaluated and possibly discontinued at any time during the project timeframe. For instance, if groundwater contaminant levels remain below the site remedial action objectives for two or three consecutive sampling events, the monitoring program may be considered for discontinuation. If contaminant levels continue to exceed the remedial action objectives at the end of the 20-yr period, the monitoring program should be extended and active remediation may be re-established and/or other remedial actions may be taken.

Inspection of the GAC vapor treatment system and monitoring of any off-gas emissions will also occur as part of the overall system monitoring. It is assumed that samples of emissions will occur every two months for the first year of system operation, and

TABLE 11-11

ALTERNATIVE 5B
GROUNDWATER EXTRACTION / AIRSTRIPPING
MONITORING PROGRAM SUMMARY [1]
NCIA Off-Site Groundwater

WELL[2]	Plume Location	DEPTH[3]	SAMPLING SCHEDULE[4] YEARS 1-2	SAMPLING SCHEDULE[5] YEARS 3-20
N-10477	West	57 ft (shallow)	X	X
N-10478	West	121 ft (intermediate)	X	X
N-11851	West	65 ft (shallow)	X	X
NRMW-4	West	70 ft (intermediate)	X	X
N-11848	West	60 ft (shallow)	X	X
N-11860	Central	60 ft (shallow)	X	X
N-11862	Central	60 ft (shallow)	X	X
N-10476	Central	130 ft (deep)	X	X
N-11861	Central	60 ft (shallow)	X	X
EW-1B	Central/East	164 ft (deep)	X	X
EW-1C	Central/East	516 ft (deep)	X	X
EW-2B	Central/East	142 ft (deep)	X	X
EW-2C	Central/East	514 ft (deep)	X	X
NRMW-1	Central/East	70 ft (intermediate)	X	X
N-9939	Central/East	74 ft (intermediate)	X	X
N-10329	East	57 ft (shallow)	X	X
6 proposed new well couplets[6]		**intermediate/deep**	X	X
		TOTAL:	**28**	**28**

X - Sampling is recommended.
1 - This is a preliminary monitoring program developed for cost estimation purposes; the final monitoring program will be established during the remedial design phase; depending on the sample results, the schedule may be modified.
2 - Well locations are depicted on Figures 3-4, 3-5, and 3-6 of the RI report.
3 - Shallow groundwater exists at depths between the water table and 64-ft; intermediate groundwater exists from approximately 65-124 ft bgs. deep groundwater exists at depths of 125 ft bgs or greater.
4 - All samples will be analyzed for VOCs quarterly
5 - All samples will be analyzed for VOCs annually
6 - For costing purposes, it is assumed that 6 new monitoring well locations will be established at locations downgradient and sidegradient of existing off-site plumes to monitor future VOC migration. It is assumed that monitoring wells will be installed at intermediate and deep depths as follows
A total of 3 intermediate wells will be installed to 70 ft bgs; the remaining 3 intermediate wells are to be installed to a depth of 100 ft bgs.
A total of 3 deep wells will be installed to 200 ft bgs; the 3 remaining deep wells are to be installed to a depth of 250 ft bgs.

semiannually after that for the duration of the alternative timeframe. As with the groundwater monitoring, the continued need for air emissions monitoring will be re-evaluated during the course of the project, and may be reduced or considered for discontinuation after system start-up.

Alternative 5B also includes the operation and maintenance, including replacement of equipment as needed, of the VOC treatment processes that are currently in-place at the Bowling Green Water District (refer to Alternative 1).

11.3.8 Alternative 6A: Full Plume Remediation of Upper Portion of Aquifer (to 125 ft bgs) with In-Well Vapor Stripping / Localized Vapor Treatment

Alternative 6A is similar to Alternative 4A presented above (i.e., addresses contamination in the upper portion of the aquifer with in-well vapor stripping) but includes the full-scale treatment of contaminated off-site groundwater to the designated depths to achieve Class GA groundwater criteria. As discussed above, active source removal and groundwater remediation is in-place or planned at 13 source sites within the NCIA. Figure 11-14 shows approximate locations of the stripping wells for Alternative 6A. Note that in addition to 80-ft and 125-ft treatment wells, containment stripper wells (installed to 150-ft bgs) are also employed under this alternative along the southern extent of the contamination (i.e., curtain wall) to achieve remedial objectives. Figure 11-15 shows average total VOC contaminant plumes (years 1996 – 2000) for depths of 65 – 125 ft bgs. Figure 11-16 displays treatment well locations and radii of influence and portions of the off-site plumes addressed in Alternative 6A.

Alternative 6A includes the treatment of the contaminated off-site groundwater via nine in-well vapor stripping wells. Alternative 6A includes the installation of one 80-ft stripper well, three 125-ft stripper wells, and five 150-ft containment wells. Table 11-5 summarizes the system components and operation parameters for Alternative 6A. As for the other in-well vapor stripping scenarios presented in this FS, pilot studies and field measurements in the design phase of work will more accurately determine the construction details and placement of each of the in-well vapor stripping wells in Alternative 6A, along with the specific groundwater circulation/treatment patterns expected to result.

Figure 11-14
Alternative 6A
In-Well Vapor Stripping
Full Plume Remediation of
Upper Portion of Aquifer
(to 125 ft BGS)

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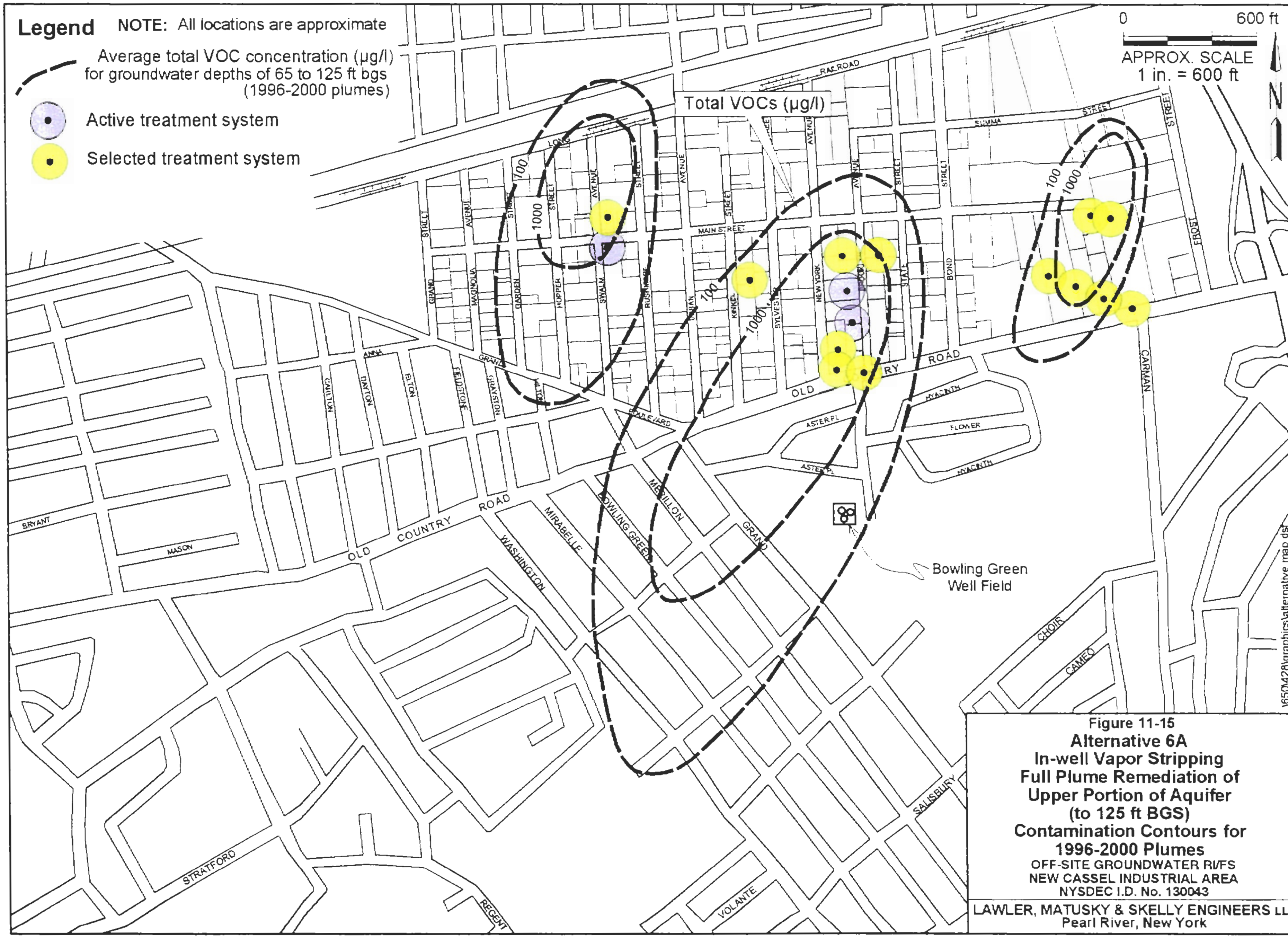

Figure 11-15
Alternative 6A
In-well Vapor Stripping
Full Plume Remediation of Upper Portion of Aquifer (to 125 ft BGS)
Contamination Contours for 1996-2000 Plumes
OFF-SITE GROUNDWATER RI/FS
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Figure 11-16
Alternative 6A
In-well Vapor Stripping
Full Plume Remediation of
Upper Portion of Aquifer (to 125 ft BGS)
Treatment Well Placement
and Contamination Contours for
1996-2000 Plumes

OFF-SITE GROUNDWATER RI/FS
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Based on the treatment technology and aquifer characteristics in the off-site area, the estimated groundwater flow rate in the 80-ft well is 40 gpm, the flow rate in the 125-ft wells is 10 gpm, and the flow rate in each containment treatment well is 10 gpm. According to venders of the in-well vapor stripping technology, the following radii of influence can be achieved for each type of stripping well in Alternative 6A: containment well: 315 ft; 80-ft well: 120 ft; and 125-ft well: 250 ft (refer to Figure 11-16).

Prior to the final design of Alternative 6A, pilot-scale treatability studies should be performed to determine the off-site groundwater remediation timeframe and specifications of the in-well vapor stripping system. A pilot scale test can also determine optimal system configurations and design parameters, such as number/location of wells, operating pressures, and flow rates to remove contaminants from the groundwater. The results of a pilot study can also be used to evaluate the airflow distribution and vapor phase treatment approaches. In addition, potential impacts from natural iron and pH in the subsurface can be better evaluated. The results of the pilot tests will also be used to better estimate the power requirements of the system. Any potential effects from in-well vapor stripping on the Bowling Green supply wells or other remediation systems (i.e., within the NCIA) can also be evaluated. For this FS, it was assumed that a total of three in-well vapor stripping pilot tests (i.e., one per off-site contaminant plume) will be conducted under Alternative 6A. It was also assumed that a full-time in-well vapor stripping system operator will be required. For the Alternative 6A cost estimate, a project life of 5 years was assumed.

11.3.8.1 ***Vapor Phase Treatment.*** For Alternative 6A, vapors from the in-well vapor stripping processes will be collected from each stripping well and transferred with a vacuum extraction blower to a GAC treatment system within each local vault. The vapors containing VOCs are passed through the GAC medium, adsorbed, and then vented to the atmosphere. GAC was selected as the optimal vapor phase treatment option for Alternative 6A based on anticipated flow rates and contaminant concentrations.

In Alternative 6A, the vapor phase flow rates to the local GAC treatment systems differ for each type of stripper well (i.e., 150-ft containment well, 80-ft well, and 125-ft well). The vapor phase flow rates (scfm, assuming 75:1 air-to-water ratio) and initial carbon usage rates are summarized for Alternative 6A in Table 11-5. As for the other in-well vapor stripping alternatives, it was assumed that as VOC concentrations in the groundwater and vapor streams are reduced over time, the carbon usage rates will also decrease. When GAC is spent (i.e., saturated with VOCs), it is transported off-site for regeneration and replaced with fresh material.

High relative humidity of the treated vapor (i.e., above about 50%) reduces the adsorption efficiency of the GAC. Thus, vacuum extraction blowers in Alternative 6A should be specified so that sufficient heat is imparted to the vapor stream and the relative humidity is maintained within satisfactory limits.

A preliminary review of the VOC constituents and respective vapor phase concentrations anticipated at each well head for the Alternative 6A scenario indicates that an emission stack will not be required. However, the ultimate configurations of the localized vapor recovery/treatment systems, including GAC usage rates over time, should be based on the final design and results from the pilot study. Air monitoring and inspection of the vapor treatment systems after startup may also determine system requirements. For cost estimating purposes, GAC was the assumed vapor phase treatment option for the in-well vapor stripping Alternative 6A. However, other vapor phase treatment options (i.e., catalytic oxidation) may be evaluated during the final design and pilot study.

11.3.8.2 ***Waste Disposal.*** Minimal trenching is required for the Alternative 6A scenario, as control of the stripper wells and vapor phase treatment occur in subsurface vaults placed near each of the treatment wells. It is estimated that approximately 470 yd^3 of nonhazardous soil will require off-site disposal from the installation of the nine stripping wells and treatment vaults in Alternative 6A. All streets and areas disturbed by installation of the remediation system will be restored to original conditions.

Conservative estimates for condensate accumulation were made for Alternative 6A (refer to Table 11-5). Condensate will be periodically collected and disposed of at an approved off-site facility. Analytical sampling of the condensate and any other materials generated during remedial activities will be conducted to characterize the wastes and identify disposal options.

11.3.8.3 ***System Performance Monitoring.*** To confirm that the in-well vapor stripping system described above for Alternative 6A is achieving remedial objectives, periodic groundwater sampling will be conducted. For cost estimating purposes, it was assumed that groundwater samples will be collected from 16 existing monitoring wells in the off-site area and analyzed for VOCs. In addition, it is assumed that six new well couplets will be installed at intermediate and deep depths (i.e., same layout as described for long-term monitoring in Alternative 2). The results of these analyses will be used to determine whether remedial action objectives are being satisfied, and whether changes in system design, configuration, and operation are required. Table 11-12 itemizes the groundwater monitoring schedule for the Alternative 6A scenario.

The continued need for monitoring can be re-evaluated and possibly discontinued at any time during the project timeframes. For instance, if groundwater contaminant levels remain below the remedial action objectives for two or three consecutive sampling events, the monitoring program may be considered for discontinuation. If contaminant levels continue to exceed the remedial action objectives at the end project life, the monitoring program, and system operation, will be extended and/or other remedial actions may be taken.

Inspection of the GAC vapor treatment system and monitoring of any off-gas emissions will also occur as part of the overall system monitoring. It is assumed that samples of emissions will occur every two months for the first year of system operation, and semiannually after that for the duration of the alternative timeframe. As with the groundwater monitoring, the continued need for air emissions monitoring will be re-evaluated during the course of the project, and may be reduced or considered for discontinuation after system start-up.

Alternative 6A also includes the operation and maintenance, including replacement of equipment as needed, of the VOC treatment processes that are currently in-place at the Bowling Green Water District (refer to Alternative 1).

11.3.9 Alternative 6B: Full Plume Remediation of Upper Portion of Aquifer (to 125 ft bgs) with Groundwater Extraction / Centralized Air Stripping and Vapor Treatment / Effluent Re-Injection

Alternative 6B is similar to Alternative 4B presented above (i.e., addresses contamination in the upper portion of the aquifer with a pump and treat system) but includes the full-scale treatment of contaminated off-site groundwater to the designated depths to achieve

TABLE 11-12

ALTERNATIVE 6A
IN-WELL VAPOR STRIPPING
MONITORING PROGRAM SUMMARY [1]
NCIA Off-Site Groundwater

WELL[2]	Plume Location	DEPTH[3]	SAMPLING SCHEDULE[4] YEARS 1-2	SAMPLING SCHEDULE[5] YEARS 3-20
N-10477	West	57 ft (shallow)	X	X
N-10478	West	121 ft (intermediate)	X	X
N-11851	West	65 ft (shallow)	X	X
NRMW-4	West	70 ft (intermediate)	X	X
N-11848	West	60 ft (shallow)	X	X
N-11860	Central	60 ft (shallow)	X	X
N-11862	Central	60 ft (shallow)	X	X
N-10476	Central	130 ft (deep)	X	X
N-11861	Central	60 ft (shallow)	X	X
EW-1B	Central/East	164 ft (deep)	X	X
EW-1C	Central/East	516 ft (deep)	X	X
EW-2B	Central/East	142 ft (deep)	X	X
EW-2C	Central/East	514 ft (deep)	X	X
NRMW-1	Central/East	70 ft (intermediate)	X	X
N-9939	Central/East	74 ft (intermediate)	X	X
N-10329	East	57 ft (shallow)	X	X
6 proposed new well couplets[6]		**intermediate/deep**	X	X
		TOTAL:	**28**	**28**

X - Sampling is recommended.
1 - This is a preliminary monitoring program developed for cost estimation purposes; the final monitoring program will be established during the remedial design phase; depending on the sample results, the schedule may be modified.
2 - Well locations are depicted on Figures 3-4, 3-5, and 3-6 of the RI report.
3 - Shallow groundwater exists at depths between the water table and 64-ft; intermediate groundwater exists from approximately 65-124 ft bgs. deep groundwater exists at depths of 125 ft bgs or greater.
4 - All samples will be analyzed for VOCs quarterly.
5 - All samples will be analyzed for VOCs annually.
6 - For costing purposes, it is assumed that 6 new monitoring well locations will be established at locations downgradient and sidegradient of existing off-site plumes to monitor future VOC migration. It is assumed that monitoring wells will be installed at intermediate and deep depths as follows:
A total of 3 intermediate wells will be installed to 70 ft bgs; the remaining 3 intermediate wells are to be installed to a depth of 100 ft bgs.
A total of 3 deep wells will be installed to 200 ft bgs; the 3 remaining deep wells are to be installed to a depth of 250 ft bgs.

Class GA groundwater criteria. As discussed above, active contaminant source removal and groundwater remediation is in-place or planned at 13 source sites within the NCIA. Figure 11-17 shows approximate locations of the extraction wells and the centralized treatment structure for Alternative 6B. On Figure 11-17, average total VOC plumes were derived from contaminant plume maps for groundwater at depths of 65 to 125 ft bgs. As shown, twelve extraction wells (one 80-ft well and eleven 110-ft wells) are included under Alternative 6B. Details and construction of the extraction wells used in Alternative 6B are as described in the other pump and treat alternatives. The bottom 20 ft of each extraction well will be screened. The central structure (approximately 4000 sf) will likely be located to the east of the Bowling Green supply wells (same location as central treatment building described for other pump and treat alternatives). The structure size and location shall be confirmed in the final design.

Table 11-7 summarizes the system components for Alternative 6B. As for the other groundwater extraction/air stripping scenarios presented in this FS, aquifer pump tests and pilot studies (i.e., one per plume) in the design phase of work will more accurately determine the construction details and placement of each of the extraction wells and recharge wet wells in Alternative 6B.

As shown in Table 11-7, the scenarios presented under Alternative 6B will utilize seven wet wells with approximate depths of 15 ft bgs for re-injection of treated groundwater to the subsurface. The wet wells will be located beside the central treatment building. Re-injection of treated water into the subsurface will require that all relevant discharge standards are achieved. In addition, local or state permits may be required. The treatability/pilot studies will help to evaluate the ability of the treatment processes to meet discharge requirements near the treatment building. Pilot studies can also help determine reinjection schedules and potential impacts of reinjection on the Bowling Green supply wells or other remediation systems (i.e., within the NCIA). If discharge limitations are not satisfied, polishing via carbon adsorption may be necessary. The treated effluent will be periodically monitored to ensure that discharge limits are met.

It is estimated that approximately 40 yd^3 of nonhazardous soil will require off-site disposal from the installation of the extraction wells in Alternative 6B. In addition, approximately 38,000 ft^2 of asphalt will also be excavated and require off-site disposal under Alternative 6B. All streets and areas disturbed by trenching and installation of the

Figure 11-17

Alternative 6B
Groundwater Extraction/ Air Stripping
Full Plume Remediation of Aquifer to 125 ft bgs

OFF-SITE GROUNDWATER RI/FS
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remediation system will be restored to original conditions. It is estimated that approximately 9,400 l.f. of trenching are required under Alternative 6B.

For Alternative 6B, it is assumed that a full-time operator will be needed to operate, supervise, and monitor the treatment system. Operation and maintenance items described for the other pump and treat alternatives (i.e., electricity; periodic repair and replacement of system parts/components; routine operator inspection of the system; and system monitoring) also apply to Alternative 6B. System inspection, maintenance, and monitoring activities consist of assessments of the remediation system, cleaning and maintaining the components, and collection of real-time air measurements, as required.

For cost estimating purposes in this FS, a project life of 7 years is assumed for Alternative 6B. This estimated remediation time should be confirmed after an aquifer pump test establishes better values for the hydrological parameters.

11.3.9.1 ***System Performance Monitoring.*** The long-term monitoring program included in this alternative is intended to assess the effectiveness of groundwater extraction and treatment on the contaminant levels in the aquifer over time. Monitoring will consist of system performance monitoring and effluent quality monitoring. For Alternative 6B, during the first three months that the treatment plant is in operation, VOC samples will be collected from the equalization tank and the effluent pipe once per week to evaluate the efficiency and effectiveness of the treatment plant. The effluent sample analysis will be used to demonstrate that all discharge requirements are being met. For the remainder of the project lives of the alternatives, VOC sampling at each of the influent pipes and the single effluent pipe at the treatment plant will be collected once per month. Samples will be analyzed for conventional parameters (e.g., pH, solids, and alkalinity) as well as VOC content. As reference, Table 11-8 lists the effluent limitations (Class GA) for the VOCs of concern.

To confirm that the groundwater extraction/air stripping system described above for Alternative 6B is achieving remedial objectives, periodic groundwater sampling will be conducted. For cost estimating purposes, it was assumed that groundwater samples will be collected from 16 existing monitoring wells in the off-site area and analyzed for VOCs. In addition, it is assumed that six new well couplets will be installed at intermediate and deep depths (i.e., same layout as described for long-term monitoring in

Alternative 2). The results of these analyses will be used to determine whether remedial action objectives are being satisfied, and whether changes in system design, configuration, and operation are required. Table 11-13 itemizes the groundwater monitoring schedule for the Alternative 6B scenario.

The continued need for groundwater monitoring can be re-evaluated and possibly discontinued at any time during the project timeframe. For instance, if groundwater contaminant levels remain below the site remedial action objectives for two or three consecutive sampling events, the monitoring program may be considered for discontinuation. If contaminant levels continue to exceed the remedial action objectives at the end of the project life, the monitoring program, and system operation, will be extended and/or other remedial actions may be taken.

Inspection of the GAC vapor treatment system and monitoring of any off-gas emissions will also occur as part of the overall system monitoring. It is assumed that samples of emissions will occur every two months for the first year of system operation, and semiannually after that for the duration of the alternative timeframe. As with the groundwater monitoring, the continued need for air emissions monitoring will be re-evaluated during the course of the project, and may be reduced or considered for discontinuation after system start-up.

Alternative 6B also includes the operation and maintenance, including replacement of equipment as needed, of the VOC treatment processes that are currently in-place at the Bowling Green Water District (refer to Alternative 1).

11.3.10 Alternative 7A: Full Plume Remediation of Upper and Deep Portions of Aquifer (to 200 ft bgs) with In-Well Vapor Stripping / Localized Vapor Treatment

Alternative 7A is similar to Alternative 5A presented above (i.e., addresses contamination in the upper and deep portions of the aquifer with in-well vapor stripping) but includes the full-scale treatment of contaminated off-site groundwater to the designated depths to achieve Class GA groundwater criteria. As discussed above, active source removal and groundwater remediation is in-place or planned at 13 source sites within the NCIA. Figure 11-18 shows approximate locations of the stripping wells for Alternative 7A.

TABLE 11-13

ALTERNATIVE 6B
GROUNDWATER EXTRACTION / AIRSTRIPPING
MONITORING PROGRAM SUMMARY [1]
NCIA Off-Site Groundwater

WELL[2]	Plume Location	DEPTH[3]	SAMPLING SCHEDULE[4] YEARS 1-2	SAMPLING SCHEDULE[5] YEARS 3-20
N-10477	West	57 ft (shallow)	X	X
N-10478	West	121 ft (intermediate)	X	X
N-11851	West	65 ft (shallow)	X	X
NRMW-4	West	70 ft (intermediate)	X	X
N-11848	West	60 ft (shallow)	X	X
N-11860	Central	60 ft (shallow)	X	X
N-11862	Central	60 ft (shallow)	X	X
N-10476	Central	130 ft (deep)	X	X
N-11861	Central	60 ft (shallow)	X	X
EW-1B	Central/East	164 ft (deep)	X	X
EW-1C	Central/East	516 ft (deep)	X	X
EW-2B	Central/East	142 ft (deep)	X	X
EW-2C	Central/East	514 ft (deep)	X	X
NRMW-1	Central/East	70 ft (intermediate)	X	X
N-9939	Central/East	74 ft (intermediate)	X	X
N-10329	East	57 ft (shallow)	X	X
6 proposed new well couplets[6]		**intermediate/deep**	X	X
		TOTAL:	**28**	**28**

X - Sampling is recommended.
1 - This is a preliminary monitoring program developed for cost estimation purposes; the final monitoring program will be established during the remedial design phase; depending on the sample results, the schedule may be modified.
2 - Well locations are depicted on Figures 3-4, 3-5, and 3-6 of the RI report.
3 - Shallow groundwater exists at depths between the water table and 64-ft, intermediate groundwater exists from approximately 65-124 ft bgs, deep groundwater exists at depths of 125 ft bgs or greater.
4 - All samples will be analyzed for VOCs quarterly.
5 - All samples will be analyzed for VOCs annually.
6 - For costing purposes, it is assumed that 6 new monitoring well locations will be established at locations downgradient and sidegradient of existing off-site plumes to monitor future VOC migration. It is assumed that monitoring wells will be installed at intermediate and deep depths as follows:
   A total of 3 intermediate wells will be installed to 70 ft bgs, the remaining 3 intermediate wells are to be installed to a depth of 100 ft bgs.
   A total of 3 deep wells will be installed to 200 ft bgs, the 3 remaining deep wells are to be installed to a depth of 250 ft bgs.

Figure 11-18

Alternative 7A
In-Well Vapor Stripping
Full Plume Remediation of Upper and Deep Portions of Aquifer (to 200 ft BGS)

OFF-SITE GROUNDWATER RI/FS
NEW CASSEL INDUSTRIAL AREA
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Treatment wells (installed to 140-ft, 200-ft, and 225-ft bgs) are employed under this alternative to achieve remedial objectives. Figure 11-19 shows average total VOC contaminant plumes (years 1996 – 2000) for depths of 65 – 200 ft bgs. Figure 11-20 displays treatment well locations and radii of influence and portions of the off-site plumes addressed in Alternative 7A.

Alternative 7A includes the treatment of the contaminated off-site groundwater via thirteen in-well vapor stripping wells. Alternative 7A includes the installation of four 140-ft stripper wells, four 200-ft stripper wells, and five 225-ft containment wells. Table 11-5 summarizes the system components and operation parameters for Alternative 7A. As for the other in-well vapor stripping scenarios presented in this FS, pilot studies and field measurements in the design phase of work will more accurately determine the construction details and placement of each of the in-well vapor stripping wells in Alternative 7A, along with the specific groundwater circulation/treatment patterns expected to result.

Based on the treatment technology and aquifer characteristics in the off-site area, the estimated groundwater flow rate in the 140-ft wells is 40 gpm, the flow rate in the 200-ft wells is 10 gpm, and the flow rate in each containment treatment well is 10 gpm. According to venders of the in-well vapor stripping technology, the following radii of influence can be achieved for each type of stripping well in Alternative 7A: 225-ft containment well: 510 ft; 140-ft well: 175 ft; and 200-ft well: 325 ft (refer to Figures 11-20).

Prior to the final design of Alternative 7A, pilot-scale treatability studies should be performed to determine the off-site groundwater remediation timeframe and specifications of the in-well vapor stripping system. A pilot scale test can also determine optimal system configurations and design parameters, such as number/location of wells, operating pressures, and flow rates to remove contaminants from the groundwater. The results of a pilot study can also be used to evaluate the airflow distribution and vapor phase treatment approaches. In addition, potential impacts from natural iron and pH in the subsurface can be better evaluated. The results of the pilot tests will also be used to better estimate the power requirements of the system. Any potential effects from in-well vapor stripping on the Bowling Green supply wells or other remediation systems (i.e., within the NCIA) can also be evaluated. For this FS, it was assumed that a total of three

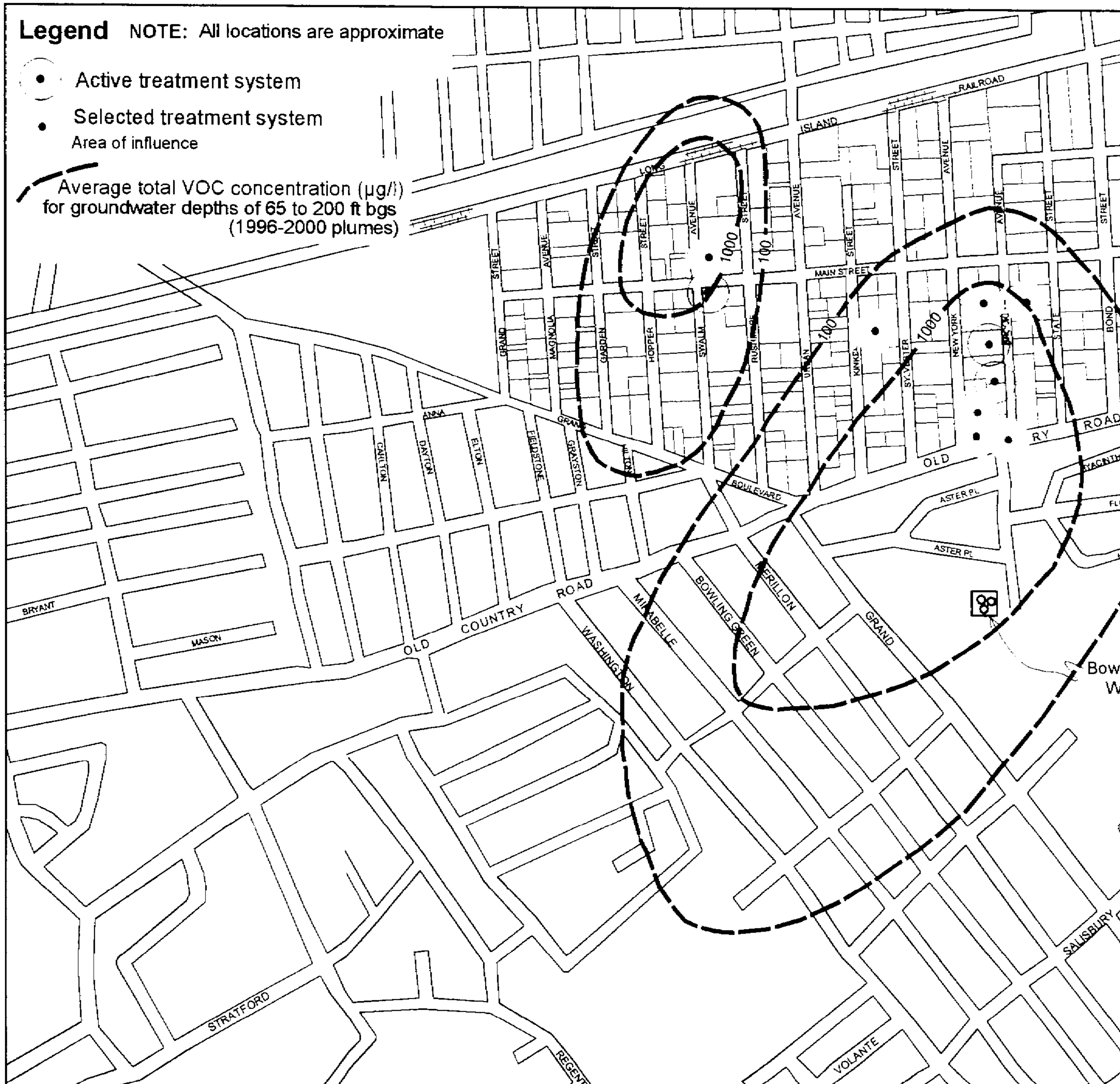

Figure 11-19
Alternative 7A
In-well Vapor Stripping Full Plume Remediation of Upper and Deep Portions of Aquifer (to 200 ft BGS) Contamination Contours for 1996-2000 Plumes

OFF-SITE GROUNDWATER RI/FS
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Figure 11-20
Alternative 7A
In-well Vapor Stripping Full Plume Remediation of Upper and Deep Portions of Aquifer (to 200 ft BGS) Treatment Well Placement and Contamination Contours for 1996-2000 Plumes

OFF-SITE GROUNDWATER RI/FS
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in-well vapor stripping pilot tests (i.e., one per off-site contaminant plume) will be conducted under Alternative 7A. It was also assumed that a full-time system operator will be needed. For the Alternative 7A cost estimate, a project life of 7 years was assumed.

11.3.10.1 ***Vapor Phase Treatment.*** For Alternative 7A, vapors from the in-well vapor stripping processes will be collected from each stripping well and transferred with a vacuum extraction blower to a GAC treatment system within each local vault. The vapors containing VOCs are passed through the GAC medium, adsorbed, and then vented to the atmosphere. GAC was selected as the optimal vapor phase treatment option for Alternative 7A based on anticipated flow rates and contaminant concentrations.

In Alternative 7A, the vapor phase flow rates to the local GAC treatment systems differ for each type of stripper well. The vapor phase flow rates (scfm, assuming 75:1 air-to-water ratio) and initial carbon usage rates are summarized for Alternative 7A in Table 11-5. As for the other in-well vapor stripping alternatives, it was assumed that as VOC concentrations in the groundwater and vapor streams are reduced over time, the carbon usage rates will also decrease. When GAC is spent (i.e., saturated with VOCs), it is transported off-site for regeneration and replaced with fresh material.

High relative humidity of the treated vapor (i.e., above about 50%) reduces the adsorption efficiency of the GAC. Thus, vacuum extraction blowers in Alternative 7A should be specified so that sufficient heat is imparted to the vapor stream and the relative humidity is maintained within satisfactory limits.

A preliminary review of the VOC constituents and respective vapor phase concentrations anticipated at each well head for the Alternative 7A scenario indicates that an emission stack will not be required. However, the ultimate configurations of the localized vapor recovery/treatment systems, including GAC usage rates over time, should be based on the final design and results from the pilot study. Air monitoring and inspection of the vapor treatment systems after startup may also determine system requirements. For cost estimating purposes, GAC was the assumed vapor phase treatment option for the in-well vapor stripping Alternative 7A. However, other vapor phase treatment options (i.e., catalytic oxidation) may be evaluated during the final design and pilot study.

11.3.10.2 ***Waste Disposal.*** Minimal trenching is required for the Alternative 7A scenario, as control of the stripper wells and vapor phase treatment occur in subsurface vaults placed near each of the treatment wells. It is estimated that approximately 680 yd^3 of nonhazardous soil will require off-site disposal from the installation of the thirteen stripping wells and treatment vaults in Alternative 7A. All streets and areas disturbed by installation of the remediation system will be restored to original conditions.

Conservative estimates for condensate accumulation were made for Alternative 7A (refer to Table 11-5). Condensate will be periodically collected and disposed of at an approved off-site facility. Analytical sampling of the condensate and any other materials generated during remedial activities will be conducted to characterize the wastes and identify disposal options.

11.3.10.3 ***System Performance Monitoring.*** To confirm that the in-well vapor stripping system described above for Alternative 7A is achieving remedial objectives, periodic groundwater sampling will be conducted. For cost estimating purposes, it was assumed that groundwater samples will be collected from 16 existing monitoring wells in the off-site area and analyzed for VOCs. In addition, it is assumed that six new well couplets will be installed at intermediate and deep depths (i.e., same layout as described for long-term monitoring in Alternative 2). The results of these analyses will be used to determine whether remedial action objectives are being satisfied, and whether changes in system design, configuration, and operation are required. Table 11-14 itemizes the groundwater monitoring schedule for the Alternative 7A scenario.

The continued need for monitoring can be re-evaluated and possibly discontinued at any time during the project timeframes. For instance, if groundwater contaminant levels remain below the remedial action objectives for two or three consecutive sampling events, the monitoring program may be considered for discontinuation. If contaminant levels continue to exceed the remedial action objectives at the end project life, the monitoring program, and system operation, will be extended and/or other remedial actions may be taken.

Inspection of the GAC vapor treatment system and monitoring of any off-gas emissions will also occur as part of the overall system monitoring. It is assumed that samples of emissions will occur every two months for the first year of system operation, and

TABLE 11-14

ALTERNATIVE 7A
IN-WELL VAPOR STRIPPING
MONITORING PROGRAM SUMMARY [1]
NCIA Off-Site Groundwater

WELL[2]	Plume Location	DEPTH[3]	SAMPLING SCHEDULE[4] YEARS 1-2	SAMPLING SCHEDULE[5] YEARS 3-20
N-10477	West	57 ft (shallow)	X	X
N-10478	West	121 ft (intermediate)	X	X
N-11851	West	65 ft (shallow)	X	X
NRMW-4	West	70 ft (intermediate)	X	X
N-11848	West	60 ft (shallow)	X	X
N-11860	Central	60 ft (shallow)	X	X
N-11862	Central	60 ft (shallow)	X	X
N-10476	Central	130 ft (deep)	X	X
N-11861	Central	60 ft (shallow)	X	X
EW-1B	Central/East	164 ft (deep)	X	X
EW-1C	Central/East	516 ft (deep)	X	X
EW-2B	Central/East	142 ft (deep)	X	X
EW-2C	Central/East	514 ft (deep)	X	X
NRMW-1	Central/East	70 ft (intermediate)	X	X
N-9939	Central/East	74 ft (intermediate)	X	X
N-10329	East	57 ft (shallow)	X	X
6 proposed new well couplets[6]		**intermediate/deep**	X	X
		TOTAL:	**28**	**28**

X - Sampling is recommended.
1 - This is a preliminary monitoring program developed for cost estimation purposes; the final monitoring program will be established during the remedial design phase; depending on the sample results, the schedule may be modified.
2 - Well locations are depicted on Figures 3-4, 3-5, and 3-6 of the RI report.
3 - Shallow groundwater exists at depths between the water table and 64-ft; intermediate groundwater exists from approximately 65-124 ft bgs deep groundwater exists at depths of 125 ft bgs or greater.
4 - All samples will be analyzed for VOCs quarterly
5 - All samples will be analyzed for VOCs annually
6 - For costing purposes, it is assumed that 6 new monitoring well locations will be established at locations downgradient and sidegradient of existing off-site plumes to monitor future VOC migration. It is assumed that monitoring wells will be installed at intermediate and deep depths as follows:
A total of 3 intermediate wells will be installed to 70 ft bgs; the remaining 3 intermediate wells are to be installed to a depth of 100 ft bgs.
A total of 3 deep wells will be installed to 200 ft bgs; the 3 remaining deep wells are to be installed to a depth of 250 ft bgs

semiannually after that for the duration of the alternative timeframe. As with the groundwater monitoring, the continued need for air emissions monitoring will be re-evaluated during the course of the project, and may be reduced or considered for discontinuation after system start-up.

Alternative 7A also includes the operation and maintenance, including replacement of equipment as needed, of the VOC treatment processes that are currently in-place at the Bowling Green Water District (refer to Alternative 1).

11.3.11 Alternative 7B: Full Plume Remediation of Upper and Deep Portions of Aquifer (to 200 ft bgs) with Groundwater Extraction / Centralized Air Stripping and Vapor Treatment / Effluent Re-Injection

Alternative 7B is similar to Alternative 5B presented above (i.e., addresses contamination in the upper and deep portions of the aquifer with a pump and treat system) but includes the full-scale treatment of contaminated off-site groundwater to the designated depths to achieve Class GA groundwater criteria. As discussed above, active contaminant source removal and groundwater remediation is in-place or planned at 13 source sites within the NCIA. Figure 11-21 shows approximate locations of the extraction wells and the centralized treatment structure for Alternative 7B. On Figure 11-21, average total VOC plumes were derived from contaminant plume maps for groundwater at depths of 65 to 200 ft bgs. As shown, thirteen extraction wells (one 80-ft well and twelve 150-ft wells) are included under Alternative 7B. Details and construction of the extraction wells used in Alternative 7B are as described in the other pump and treat alternatives. The bottom 20 ft of each extraction well will be screened. It is assumed under Alternative 7B that the 150-ft extraction wells will remove groundwater contaminants from depths as great as 200 ft bgs. This assumption, and final extraction well details, should be confirmed during pilot studies and in the final design phase of work. The central structure (approximately 4000 sf) will likely be located to the east of the Bowling Green supply wells (same location as central treatment building described for other pump and treat alternatives). The structure size and location shall be confirmed in the final design.

Table 11-7 summarizes the system components for Alternative 7B. As for the other groundwater extraction/air stripping scenarios presented, aquifer pump tests and pilot studies (i.e., one per plume) in the design phase of work will more accurately determine

Figure 11-21

Alternative 7B
Groundwater Extraction/Air Stripping
Full Plume Remediation of
Aquifer to 200 ft bgs

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the construction details and placement of each of the extraction wells and recharge wet wells in Alternative 7B.

As shown in Table 11-7, the scenarios presented under Alternative 7B will utilize eight wet wells with approximate depths of 15 ft bgs for re-injection of treated groundwater to the subsurface. The wet wells will be located beside the central treatment building. Re-injection of treated water into the subsurface will require that all relevant discharge standards are achieved. In addition, local or state permits may be required. The treatability/pilot studies will help to evaluate the ability of the treatment processes to meet discharge requirements near the treatment building. Pilot studies can also help determine reinjection schedules and potential impacts of reinjection on the Bowling Green supply wells or other remediation systems (i.e., within the NCIA). If discharge limitations are not satisfied, polishing via carbon adsorption may be necessary. The treated effluent will be periodically monitored to ensure that discharge limits are met.

It is estimated that approximately 60 yd^3 of nonhazardous soil will require off-site disposal from the installation of the extraction wells in Alternative 7B. In addition, approximately 41,000 ft^2 of asphalt will also be excavated and require off-site disposal under Alternative 7B. All streets and areas disturbed by trenching and installation of the remediation system will be restored to original conditions. It is estimated that approximately 10,300 l.f. of trenching are required under Alternative 7B.

For Alternative 7B, it is assumed that a full-time operator will be needed to operate, supervise, and monitor the treatment system. Operation and maintenance items described for the other pump and treat alternatives (i.e., electricity; periodic repair and replacement of system parts/components; routine operator inspection of the system; and system monitoring) also apply to Alternative 7B. System inspection, maintenance, and monitoring activities consist of assessments of the remediation system, cleaning and maintaining the components, and collection of real-time air measurements, as required.

For cost estimating purposes in this FS, a project life of 10 years is assumed for Alternative 7B. Although overall flowrates and numbers of extraction wells are similar to the Alternative 6B scenario, a longer project life was assumed for Alternative 7B since greater quantities of contaminated groundwater are addressed. This estimated remediation time should be confirmed after an aquifer pump test establishes better values for the hydrological parameters.

11.3.11.1 ***System Performance Monitoring.*** The long-term monitoring program included in this alternative is intended to assess the effectiveness of groundwater extraction and treatment on the contaminant levels in the aquifer over time. Monitoring will consist of system performance monitoring and effluent quality monitoring. For Alternative 7B, during the first three months that the treatment plant is in operation, VOC samples will be collected from the equalization tank and the effluent pipe once per week to evaluate the efficiency and effectiveness of the treatment plant. The effluent sample analysis will be used to demonstrate that all discharge requirements are being met. For the remainder of the project lives of the alternatives, VOC sampling at each of the influent pipes and the single effluent pipe at the treatment plant will be collected once per month. Samples will be analyzed for conventional parameters (e.g., pH, solids, and alkalinity) as well as VOC content. As reference, Table 11-8 lists the effluent limitations (Class GA) for the VOCs of concern.

To confirm that the groundwater extraction/air stripping system described above for Alternative 7B is achieving remedial objectives, periodic groundwater sampling will be conducted. For cost estimating purposes, it was assumed that groundwater samples will be collected from 16 existing monitoring wells in the off-site area and analyzed for VOCs. In addition, it is assumed that six new well couplets will be installed at intermediate and deep depths (i.e., same layout as described for long-term monitoring in Alternative 2). The results of these analyses will be used to determine whether remedial action objectives are being satisfied, and whether changes in system design, configuration, and operation are required. Table 11-15 itemizes the groundwater monitoring schedule for the Alternative 7B scenario.

The continued need for groundwater monitoring can be re-evaluated and possibly discontinued at any time during the project timeframe. For instance, if groundwater contaminant levels remain below the site remedial action objectives for two or three consecutive sampling events, the monitoring program may be considered for discontinuation. If contaminant levels continue to exceed the remedial action objectives at the end of the project life, the monitoring program, and system operation, will be extended and/or other remedial actions may be taken.

TABLE 11-15

ALTERNATIVE 7B
GROUNDWATER EXTRACTION / AIRSTRIPPING
MONITORING PROGRAM SUMMARY [1]
NCIA Off-Site Groundwater

WELL[2]	Plume Location	DEPTH[3]	SAMPLING SCHEDULE[4] YEARS 1-2	SAMPLING SCHEDULE[5] YEARS 3-20
N-10477	West	57 ft (shallow)	X	X
N-10478	West	121 ft (intermediate)	X	X
N-11851	West	65 ft (shallow)	X	X
NRMW-4	West	70 ft (intermediate)	X	X
N-11848	West	60 ft (shallow)	X	X
N-11860	Central	60 ft (shallow)	X	X
N-11862	Central	60 ft (shallow)	X	X
N-10476	Central	130 ft (deep)	X	X
N-11861	Central	60 ft (shallow)	X	X
EW-1B	Central/East	164 ft (deep)	X	X
EW-1C	Central/East	516 ft (deep)	X	X
EW-2B	Central/East	142 ft (deep)	X	X
EW-2C	Central/East	514 ft (deep)	X	X
NRMW-1	Central/East	70 ft (intermediate)	X	X
N-9939	Central/East	74 ft (intermediate)	X	X
N-10329	East	57 ft (shallow)	X	X
6 proposed new well couplets[6]		**intermediate/deep**	X	X
		TOTAL:	**28**	**28**

X - Sampling is recommended.
1 - This is a preliminary monitoring program developed for cost estimation purposes; the final monitoring program will be established during the remedial design phase; depending on the sample results, the schedule may be modified.
2 - Well locations are depicted on Figures 3-4, 3-5, and 3-6 of the RI report.
3 - Shallow groundwater exists at depths between the water table and 64-ft, intermediate groundwater exists from approximately 65-124 ft bgs, deep groundwater exists at depths of 125 ft bgs or greater.
4 - All samples will be analyzed for VOCs quarterly.
5 - All samples will be analyzed for VOCs annually.
6 - For costing purposes, it is assumed that 6 new monitoring well locations will be established at locations downgradient and sidegradient of existing off-site plumes to monitor future VOC migration. It is assumed that monitoring wells will be installed at intermediate and deep depths as follows:
A total of 3 intermediate wells will be installed to 70 ft bgs; the remaining 3 intermediate wells are to be installed to a depth of 100 ft bgs.
A total of 3 deep wells will be installed to 200 ft bgs; the 3 remaining deep wells are to be installed to a depth of 250 ft bgs.

Inspection of the GAC vapor treatment system and monitoring of any off-gas emissions will also occur as part of the overall system monitoring. It is assumed that samples of emissions will occur every two months for the first year of system operation, and semiannually after that for the duration of the alternative timeframe. As with the groundwater monitoring, the continued need for air emissions monitoring will be re-evaluated during the course of the project, and may be reduced or considered for discontinuation after system start-up.

Alternative 7B also includes the operation and maintenance, including replacement of equipment as needed, of the VOC treatment processes that are currently in-place at the Bowling Green Water District (refer to Alternative 1).

CHAPTER 12

DETAILED EVALUATION OF GROUNDWATER RESPONSE ALTERNATIVES

12.1 INTRODUCTION

This chapter presents the detailed evaluation of the remedial alternatives described in Chapter 11. The purpose of the evaluation is to identify the advantages and disadvantages of each alternative as well as key tradeoffs among the alternatives. The following criteria are used to evaluate the remedial alternatives in accordance with the NYSDEC TAGM HWR-90-4030, "Selection of Remedial Actions at Inactive Hazardous Waste Sites".

- **Overall Protection of Human Health and the Environment:** This criterion evaluates the extent to which the alternative will achieve and maintain protection of human health and the environment and how the protection will be achieved, i.e., through treatment, engineering, or institutional controls.

- **Compliance with SCGs:** This criterion evaluates the compliance of the alternative with all identified chemical-, location-, and action-specific SCGs. Chemical-specific SCGs for the off-site groundwater COCs are listed in Chapter 7. Remedial alternatives were also developed for this FS in accordance with TAGM HWR-90-4030.

- **Reduction of Toxicity, Mobility, and Volume Through Treatment:** The NCP specifies that preference be given to alternatives that reduce the toxicity, mobility, or volume of contamination present through treatment. The degree to which each alternative results in a reduction is evaluated by this criterion.

- **Short-Term Effectiveness:** This criterion evaluates the impacts of each alternative on human health and the environment during the construction and implementation of the remedy.

- **Long-Term Effectiveness and Permanence:** Each alternative is evaluated for its long-term effectiveness in protecting human health and the environment following completion of the remedial action.

- **Implementability:** The technical and administrative feasibility of implementing each alternative, including site features that may restrict application of the alternative, are evaluated for this criterion.

- **Cost:** The relative capital costs have been estimated for each alternative. Operation and maintenance (O&M) costs range from an assumed 30 years for No Further Action, MNA, and Monitoring, Assessment, and Contingent Remediation to the projected times of a few years for the active remedies. The total present worth costs associated with the active remediation-based alternatives are evaluated over the anticipated system operating times (depending on the alternative) with additional years of concurrent groundwater monitoring. The cost estimates included in this FS are for comparative purposes; detailed cost estimates are prepared in the remedial design phase.

Community acceptance, the eighth criterion, is also to be considered in evaluating the remedial alternatives. Community acceptance cannot be assessed until public comments have been received on the RI/FS report and proposed remedial action plan. The ROD for the NCIA off-site groundwater will address public comments.

12.2 INDIVIDUAL ANALYSIS OF ALTERNATIVES

The individual analysis of the eleven groundwater response alternatives with respect to the evaluation criteria is presented below and is summarized in Table 12-1. The analysis of all clean-up scenarios under the active remediation alternatives (i.e., Alternatives 4A, 4B, 5A, 5B, 6A, 6B, 7A, and 7B) are also included in Table 12-1.

12.2.1 Alternative 1: No Further Action

12.2.1.1 ***Protection of Human Health and the Environment.*** Institutional measures included in Alternative 1 serve to protect human health by preventing human contact with the contaminants that will remain in the off-site groundwater. While the potential for human exposure to the contaminants in the groundwater will remain, treatment of groundwater (i.e., air stripping and GAC adsorption) by the Bowling Green Water District prior to distribution into the public water supply system prevents exposure to groundwater contaminants. However, the off-site contamination may continue to impact the surrounding environment through the migration of VOCs through the groundwater.

TABLE 12-1 (Page 1 of 3)

SUMMMARY OF DETAILED EVALUATION OF REMEDIAL ALTERNATIVES
NCIA Off-Site Groundwater

ALTERNATIVE	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	COMPLIANCE WITH SCGs	REDUCTION OF TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS AND PERMANENCE	IMPLEMENTABILITY	COST	
ALTERNATIVE 1: No Further Action	Minimal prevention of human contact through institutional controls only. Contaminants remain in the environment.	Will not quickly or actively achieve groundwater SCGs.	May allow natural processes to dissipate groundwater contaminants, but will not create any reduction in the toxicity, mobility, or volume of groundwater contaminants as no active remedial measures are included.	Does not result in disruption of normal residential/institutional activities or pose a short term threat to health or the environment.	Does not provide long-term effectiveness or permanence; contaminants will remain in the groundwater.	No major constraints to implementation of institutional measures.	Capital: O&M: Present Worth:	$0 $1,276,000 $1.5million
ALTERNATIVE 2: Monitored Natural Attenuation	Minimal prevention of human contact through institutional controls. Contaminants anticipated to remain in groundwater for several years.	Relies solely on natural attenuation to achieve site SCGs. Will not quickly achieve groundwater SCGs.	Relies on natural attenuation to reduce toxicity, mobility, and volume of contamination present in the groundwater. There is some evidence of natural attenuation occurring in off-site groundwater; however, it is not as effective as active remedies in reducing toxicity, mobility, and volume of VOCs.	Does not result in disruption of normal residential/institutional activities or pose a short term threat to health or the environment.	Contaminants expected to remain in off-site groundwater for long period of time.	No major constraints to implementation of institutional measures and monitoring.	Capital O&M: Present Worth:	$304,000 $2,095,000 $2.4 million
ALTERNATIVE 3: Monitoring, Assessment, and Contingent Remediation	Minimal prevention of human contact through institutional controls only. Contaminants remain in the environment. However, a technical evaluation of data and remedial options that is to be made annually may lead to implementation of an active remedy (i.e., Alternative 5A).	Will not quickly or actively achieve groundwater SCGs. However, a technical evaluation of data and remedial options that is to be made on a yearly basis may lead to implementation of an active remedy.	May allow natural processes to dissipate groundwater contaminants, but will not create any reduction in the toxicity, mobility, or volume of groundwater contaminants as no active remedial measures are included. However, a technical evaluation of data and remedial options that is to be made on a yearly basis may lead to implementation of an active remedy.	Does not result in disruption of normal residential/institutional activities or pose a short term threat to health or the environment. However, an annual technical evaluation of data and remedial options may lead to implementation of an active remedy.	Does not provide long-term effectiveness or permanence; contaminants will remain in the groundwater. However, an annual technical evaluation of data and remedial options may lead to implementation of an active remedy.	No major constraints to implementation of institutional measures and monitoring. However, the implementability of a remedial system (i.e., Alternative 5A) that may be installed in future years will be assessed.	Capital: O&M: Present Worth:	$162,000 $2,051,000 $2.2 million
ALTERNATIVE 4A: Remediation of Upper Portion of Aquifer (to 125 ft bgs) with In-Well Vapor Stripping/ Localized Vapor Delivery and Treatment	Protects human health and the environment by transferring contaminants from the water phase to the vapor phase and treating it ex-situ. Prevents further downgradient migration of groundwater contaminants that exist at 125 ft bgs and shallower, but addresses only "hot spot" areas. Not as protective as other in-well vapor stripping alternatives.	"Hot spot" remediation only. Natural attenuation anticipated to achieve groundwater standards over time. Only groundwater contamination in upper portion of aquifer is addressed. Air emissions will be controlled to meet SCGs.	Reduces the mobility and volume of VOCs in the off-site groundwater through in-situ treatment of the groundwater, but less reduction than in Alternative 5, 6, or 7.	Will result in disruption of normal residential/institutional activities during implementation of 4 treatment wells and local subsurface vaults. However, no extensive piping/trenching or large treatment building are required. Will generate some noise and traffic, but less than other in-well vapor stripping alternatives.	The operating time for this in-well vapor stripping system is estimated at 7 years. Technology permanently removes captured VOCs, but only "hot spot" areas in upper portion of aquifer are targeted. 13 years of natural attenuation assumed subsequent to active treatment to achieve remedial objectives.	Equipment for in-well vapor stripping technology is sold by a limited number of vendors. Equipment installation is readily implementable and available, depending on site logistics. Treatment wells and vaults can be located in streets (little or no land acquisition required).	Capital: O&M: Present Worth:	$838,000 $1,981,000 $2.8 million

SUMMMARY OF DETAILED EVALUATION OF REMEDIAL ALTERNATIVES
NCIA Off-Site Groundwater

ALTERNATIVE	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	COMPLIANCE WITH SCGs	REDUCTION OF TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS AND PERMANENCE	IMPLEMENTABILITY	COST	
ALTERNATIVE 4B: Remediation of Upper Portion of Aquifer (to 125 ft bgs) with Groundwater Extraction/ Centralized Air Stripping and Vapor Treatment/ Effluent Re-Injection	Protects human health and the environment by extracting contaminated groundwater from the aquifer and treating it ex-situ. Prevents further downgradient migration of groundwater contaminants that exist at 125 ft bgs and shallower, but addresses only "hot spot" areas. Not as protective as other pump and treat alternatives.	"Hot spot" remediation only. Natural attenuation anticipated to achieve groundwater standards over time. Only groundwater contamination in upper portion of aquifer is addressed. Air emissions and treated effluent discharge will be controlled to meet SCGs.	Reduces volume and mobility of contaminants in groundwater through extraction; VOCs in extracted groundwater reduced by treatment. Less reduction than in Alternative 5, 6, or 7.	Will result in disruption of normal residential/institutional activities during implementation of 4 extraction wells, piping, and an approximately 3200 s.f. central treatment building. Less piping/trenching than other pump and treat alternatives. Will generate some noise and traffic.	The estimated operating time for this pump and treat system is 9 years. Technology permanently removes captured VOCs, but only "hot spot" areas in upper portion of aquifer are targeted. 11 years of natural attenuation assumed subsequent to active treatment to achieve remedial objectives.	Well and piping installation and treatment facility construction can be readily implemented, depending on site logistics. Treated water must be re-injected to subsurface. Land will likely need to be acquired for central treatment building and wet wells for groundwater re-injection.	Capital: O&M: Present Worth:	$2,328,000 $2,624,000 $5.0 million
ALTERNATIVE 5A: Remediation of Upper and Deep Portions of Aquifer (to 200ft bgs) with In-Well Vapor Stripping/ Localized Vapor Delivery and Treatment	Protects human health and the environment by transferring contaminants from the water phase to the vapor phase and treating it ex-situ. Prevents further downgradient migration of contaminants, but addresses only "hot spot" areas. More protective than Alternative 4A, as both upper and deep portions of aquifer are addressed.	"Hot spot" remediation only. Natural attenuation anticipated to achieve groundwater standards over time. Air emissions will be controlled to meet SCGs.	Reduces the mobility and volume of VOCs in the off-site groundwater through in-situ treatment of the groundwater, but less reduction than in Alternative 6 or 7.	Will result in disruption of normal residential/institutional activities during implementation of 6 treatment wells and local subsurface vaults. However, no extensive piping/trenching or large treatment building are required. Will generate some noise and traffic, but less than Alternatives 6A and 7A.	The operating time for this in-well vapor stripping system is estimated at 9 years. Technology permanently removes captured VOCs, but only "hot spot" areas in upper and deep portions of aquifer are targeted. 11 years of natural attenuation assumed subsequent to active treatment to achieve remedial objectives.	Equipment for in-well vapor stripping technology is sold by a limited number of vendors. Equipment installation is readily implementable and available, depending on site logistics. Treatment wells and vaults can be located in streets (little or no land acquisition required).	Capital: O&M: Present Worth:	$1,164,000 $2,392,000 $3.6 million
ALTERNATIVE 5B: Remediation of Upper and Deep Portions of Aquifer (to 200 ft bgs) with Groundwater Extraction/ Centralized Air Stripping and Vapor Treatment/ Effluent Re-Injection	Protects human health and the environment by extracting contaminated groundwater from the aquifer and treating it ex-situ. Prevents further downgradient migration of contaminants, but addresses only "hot spot" areas. More protective than Alternative 4B, as both upper and deep portions of aquifer are addressed.	"Hot spot" remediation only. Natural attenuation anticipated to achieve groundwater standards over time. Air emissions and treated effluent discharge will be controlled to meet SCGs.	Reduces volume and mobility of contaminants in groundwater through extraction. VOCs in extracted groundwater reduced by treatment. Less reduction than in Alternative 6 or 7.	Will result in disruption of normal residential/institutional activities during implementation of 4 extraction wells, piping, and an approximately 3200 s.f. central treatment building. Less piping/trenching than other pump and treat alternatives. Will generate some noise and traffic.	The estimated operating time for this pump and treat system is 12 years. Technology permanently removes captured VOCs, but only "hot spot" areas in upper and deep portions of aquifer are targeted. 8 years of natural attenuation assumed subsequent to active treatment to achieve remedial objectives.	Well and piping installation and treatment facility construction can be readily implemented, depending on site logistics. Treated water must be re-injected to subsurface. Land will likely need to be acquired for central treatment building and wet wells for groundwater re-injection.	Capital: O&M: Present Worth:	$2,401,000 $2,899,000 $5.3 million
ALTERNATIVE 6A: Full Plume Remediation of Upper Portion of Aquifer (to 125ft bgs) with In-Well Vapor Stripping/ Localized Vapor Delivery and Treatment	Protects human health and the environment by transferring contaminants from the water phase to the vapor phase and treating it ex-situ. Prevents further downgradient migration of contaminants that exist at 125 ft bgs and shallower. Class GA groundwater standards are achieved at designated depths. Thus, more protective than Alternative 4A.	Achieves applicable groundwater standards. However, only contamination in upper portion of aquifer is addressed. Air emissions will be controlled to meet SCGs.	Reduces the mobility and volume of VOCs in the off-site groundwater through in-situ treatment of the groundwater.	Will result in disruption of normal residential/institutional activities during implementation of 9 treatment wells and local subsurface vaults. However, no extensive piping/trenching or large treatment building are required. Will generate some noise and traffic.	The operating time for this in-well vapor stripping system is estimated at 5 years. Technology permanently removes captured VOCs.	Equipment for in-well vapor stripping technology is sold by a limited number of vendors. Equipment installation is readily implementable and available, depending on site logistics. Treatment wells and vaults can be located in streets (little or no land acquisition required).	Capital: O&M: Present Worth:	$1,434,000 $2,238,000 $3.7 million

SUMMMARY OF DETAILED EVALUATION OF REMEDIAL ALTERNATIVES
NCIA Off-Site Groundwater

ALTERNATIVE	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	COMPLIANCE WITH SCGs	REDUCTION OF TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS AND PERMANENCE	IMPLEMENTABILITY	COST	
ALTERNATIVE 6B: Full Plume Remediation of Upper Portion of Aquifer (to 125 ft bgs) with Groundwater Extraction/ Centralized Air Stripping and Vapor Treatment/ Effluent Re-Injection	Protects human health and the environment by extracting contaminated groundwater from the aquifer and treating it ex-situ. Prevents further down-gradient migration of contaminants that exist at 125 ft bgs and shallower. Class GA groundwater standards are achieved at designated depths. Thus, more protective than Alternative 4B.	Achieves applicable groundwater standards. However,only contamination in upper portion of aquifer is addressed. Air emissions and treated effluent discharge will be controlled to meet SCGs.	Reduces volume and mobility of contaminants in groundwater through extraction; VOCs in extracted groundwater reduced by treatment.	Will result in disruption of normal residential/institutional activities during implementation of 12 extraction wells, piping, and an approximately 4000 s.f. central treatment building. Will generate some noise and traffic.	The estimated operating time for this pump and treat system is 7 years. Technology permanently removes captured VOCs.	Well and piping installation and treatment facility construction can be readily implemented, depending on site logistics. Treated water must be re-injected to subsurface. Land will likely need to be acquired for central treatment building and wet wells for groundwater re-injection.	Capital: O&M: Present Worth:	$3,848,000 $3,241,000 $7.1 million
ALTERNATIVE 7A: Full Plume Remediation of Upper and Deep Portions of Aquifer (to 200ft bgs) with In-Well Vapor Stripping/ Localized Vapor Delivery and Treatment	Protects human health and the environment by transferring contaminants from the water phase to the vapor phase and treating it ex-situ. Prevents further downgradient migration of contaminants. Class GA groundwater standards are achieved at designated depths. Both upper and deep portions of aquifer are addressed. Most protective in-well vapor stripping alternative.	Achieves applicable groundwater standards. Air emissions will be controlled to meet SCGs.	Reduces the mobility and volume of VOCs in the off-site groundwater through in-situ treatment of the groundwater. Most reduction of all in-well vapor stripping alternatives.	Will result in disruption of normal residential/institutional activities during implementation of 13 treatment wells and local subsurface vaults. However, no extensive piping/trenching or large treatment building are required. Will generate some noise and traffic.	The operating time for this in-well vapor stripping system is estimated at 7 years. Technology permanently removes captured VOCs.	Equipment for in-well vapor stripping technology is sold by a limited number of vendors. Equipment installation is readily implementable and available, depending on site logistics. Treatment wells and vaults can be located in streets (little or no land acquisition required).	Capital: O&M: Present Worth:	$2,108,000 $2,833,000 $4.9 million
ALTERNATIVE 7B: Full Plume Remediation of Upper and Deep Portions of Aquifer (to 200 ft bgs) with Groundwater Extraction/ Centralized Air Stripping and Vapor Treatment/ Effluent Re-Injection	Protects human health and the environment by extracting contaminated groundwater from the aquifer and treating it ex-situ. Prevents further down-gradient migration of contaminants. Class GA groundwater standards are achieved at designated depths. Both upper and deep portions of aquifer are addressed. Most protective pump and treat alternative.	Achieves applicable groundwater standards. Air emissions and treated effluent discharge will be controlled to meet SCGs.	Reduces volume and mobility of contaminants in groundwater through extraction; VOCs in extracted groundwater reduced by treatment. Most reduction of all pump and treat alternatives.	Will result in disruption of normal residential/institutional activities during implementation of 13 extraction wells, piping, and an approximately 4000 s.f. central treatment building. Will generate some noise and traffic.	The estimated operating time for this pump and treat system is 10 years. Technology permanently removes captured VOCs.	Well and piping installation and treatment facility construction can be readily implemented, depending on site logistics. Treated water must be re-injected to subsurface. Land will likely need to be acquired for central treatment building and wet wells for groundwater re-injection.	Capital: O&M: Present Worth:	$4,251,000 $3,935,000 $8.2 million

12.2.1.2 ***Compliance With SCGs.*** Since this alternative does not include an active remedial measure, it is highly unlikely that NYSDEC Class GA groundwater standards will be achieved in a short time frame.

Because this alternative does not include any active remedial measures, no air releases are expected; therefore no National Ambient Air Quality Standards (NAAQS) apply. As no active remedy is proposed under Alternative 1, location-specific SCGs do not apply. As Alternative 1 does not include any active remediation activities, there are no action-specific TBCs that apply to this alternative.

Alternative 1 does not comply with the Federal or state requirements which state that the selected remedial alternative must attain a cleanup level that eliminates, reduces, or controls risks to human health and the environment.

12.2.1.3 ***Reduction of Toxicity, Mobility, and Volume Through Treatment.*** Alternative 1 will not result in a substantial reduction in the toxicity, mobility, or volume of the contaminated groundwater.

12.2.1.4 ***Short-Term Effectiveness.*** Alternative 1 will not result in short-term human or environmental impacts as no activities will occur.

12.2.1.5 ***Long-Term Effectiveness and Permanence.*** Alternative 1 does not provide a high degree of long-term effectiveness and permanence, hence environmental degradation may continue to occur due to the migration of contaminants. Although human health risks may be mitigated through the use of development and groundwater use restrictions, these institutional measures may not eliminate the potential for human exposure to groundwater contaminants in downgradient areas.

12.2.1.6 ***Implementability.*** Implementation of this alternative is straightforward and should not depend on the availability of vendors, materials, or services. Development and groundwater use restrictions would be implemented by NYSDEC or the municipality.

12.2.1.7 ***Cost.*** Capital costs included in Alternative 1 are related to legal and administrative costs associated with implementing institutional measures (the costs of which would be determined in the future depending on how the institutional measures are implemented). Estimated long-term O&M costs, including the operation and maintenance of the Bowling Green VOC treatment processes, are included in Table 12-2. These costs are based on the assumptions included in the description of the alternative provided in Chapter 11 and have a range of accuracy of -30 to +50%. Annual O&M costs are estimated on a 30-year implementation basis and based on a 5% discount rate (EPA 1988) to estimate the present worth cost.

12.2.2 Alternative 2: Monitored Natural Attenuation

12.2.2.1 ***Protection of Human Health and the Environment.*** Institutional measures included in Alternative 2 serve to protect human health by preventing human contact with the contaminants that will remain in the off-site groundwater. While the potential for human exposure to the contaminants will remain, treatment of groundwater (i.e., air stripping and GAC adsorption) by the Bowling Green Water District prior to distribution into the public water supply system prevents exposure to groundwater contaminants. However, the contamination may continue to impact the surrounding environment through the migration of VOCs in groundwater. MNA monitoring and long-term groundwater monitoring, as included in this alternative, are not protective of human health and the environment, but will assess any migration or natural attenuation of the contaminant plumes over time to document the nature of any continued risk posed by the contamination.

12.2.2.2 ***Compliance With SCGs.*** Since this alternative relies solely on natural attenuation processes to remediate groundwater, it is highly unlikely that NYSDEC Class GA groundwater standards will be achieved in a short time frame.

Because this alternative does not include any active remedial measures, no air releases are expected; therefore no NAAQS apply. As no active remedy is proposed under Alternative 2, location-specific SCGs do not apply. As Alternative 2 does not include any active remediation activities, there are no action-specific SCGs that apply to this alternative. As no on-site remedial activities are included as part of this alternative, requirements of other TBCs do not apply to this alternative either.

Alternative 2 partially complies with the Federal or state requirements which state that the selected remedial alternative must attain a cleanup level that eliminates, reduces, or controls risks to human health and the environment. Under this alternative, off-site groundwater contaminants will be naturally attenuated in-situ.

TABLE 12-2

COST ESTIMATE FOR ALTERNATIVE 1: NO FURTHER ACTION

NCIA Off-Site Groundwater

ITEM	UNIT COST ($)[a]	QUANTITY	COST (2000 $)[b]	Present Worth Cost
CAPITAL COSTS				
A. Direct Costs				
Institutional Measures				
Development restrictions			- c	
Groudwater use restrictions			- c	
		Subtotal	$0	
B. Indirect Costs				
		Total	$0	
O&M COSTS				
Operation and maintenance of Bowling Green VOC treatment processes (years 1-30)				
Replacement of air stripping tower after year 20	$200,000 /rplmt	1 rplmt	$200,000	**$200,000**
GAC vessel O&M (includes vessel replacement every 10 yrs and GAC change-out)	$2,300 /month	12 months	$27,600 /yr	
Air Stripper O&M	$1,000 /month	12 months	$12,000 /yr	
Control/Electrical system O&M	$3,500 /yr	1 years	$3,500 /yr	
Electricity	$2,300 /month	12 months	$27,600 /yr	
Administrative costs	$1,000 /month	12 months	$12,000 /yr	
		Annual O&M cost for year 2000:	$83,000 /yr	**$1,276,000**
PRESENT WORTH				
Based on a 30-yr life and a 5% discount rate				***$1,476,000***
				SAY $ 1.5 million

a - Unit costs are for year 2000.
b - Costs rounded to the nearest $1,000.
c - Legal and administrative costs to community that are not included in cost estimate.
LS - Lump sum.

12.2.2.3 ***Reduction of Toxicity, Mobility, and Volume Through Treatment.*** Alternative 2 may result in a reduction in the toxicity, mobility, or volume of contamination present by means of in-situ natural attenuation processes. However, transformation products that are more toxic and mobile than parent compounds may possibly result. As noted in Chapter 11, there is limited to adequate evidence that natural attenuation will degrade the off-site groundwater contamination. This is based on the natural attenuation screening protocol produced from the BioChlor software. As shown in Figure 12-1, a score of 13 ("limited evidence for anaerobic biodegradation of chlorinated organics") was produced from the sum of several natural attenuation parameters. Since no data were obtained for three of the evaluation parameters (sulfide, carbon dioxide, and hydrogen), values of zero were assigned. Thus, it is possible that the natural attenuation score may actually be greater than 13 and possibly in the range of "adequate evidence for anaerobic biodegradation of chlorinated organics".

12.2.2.4 ***Short-Term Effectiveness.*** Alternative 2 will result in minimal short-term human or environmental impacts as the only active remedial activities that will occur at the off-site area include the installation of monitoring wells and sampling of existing and new wells. As sampling has already been accomplished without causing negative short-term effects, sampling conducted in the future is not expected to have adverse impacts.

12.2.2.5 ***Long-Term Effectiveness and Permanence.*** Alternative 2 is intended to reduce VOC concentrations in the off-site groundwater through natural attenuation processes. The estimated time frame for the MNA alternative is 30 years; however, the actual time frame may be longer or shorter. Appendix J includes attenuation projections from the BioChlor software for the off-site groundwater COCs. Periodic monitoring of natural attenuation processes for the off-site groundwater will be performed. An enhanced site characterization program (i.e., pilot) may lead to better estimates of the time frame for this alternative. Although human health risks may be minimized during the estimated 30-year alternative duration through the use of development and groundwater restrictions, these institutional measures may not eliminate the potential for human exposure to contaminants (e.g., groundwater uptake in downgradient areas). However, continued treatment of the groundwater supply for potable purposes (as is currently done) will minimize the potential for human exposure to the NCIA off-site groundwater contaminants.

12.2.2.6 ***Implementability.*** Implementation of this alternative is straightforward and should not depend on the availability of vendors, materials, or services. Development and

Figure 12-1

Natural Attenuation Screening Protocol	Interpretation	Score	
The following is taken from the USEPA protocol (USEPA 1998). The results of this scoring process have no regulatory significance	Inadequate evidence for anaerobic biodegradation* of chlorinated organics	0 to 5	Score: 13
	Limited evidence for anaerobic biodegradation* of chlorinated organics	6 to 14	
	Adequate evidence for anaerobic biodegradation* of chlorinated organics	15 to 20	
	Strong evidence for anaerobic biodegradation* of chlorinated organics	>20	*Scroll to End of Table*

(0-7)±

* reductive dechlorination

Analysis	Concentration in Most Contam. Zone	Interpretation	Yes	No	Points Awarded	
Oxygen*	<0.5 mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	○	●	0	
	>5mg/L	Not tolerated; however, VC may be oxidized aerobically	●	○	-3	
Nitrate*	<1 mg/L	At higher concentrations may compete with reductive pathway	○	●	0	
Iron II*	>1 mg/L	Reductive pathway possible; VC may be oxidized under Fe(III)-reducing conditions	●	○	3	
Sulfate*	<20 mg/L	At higher concentrations may compete with reductive pathway	○	●	0	
Sulfide*	>1 mg/L	Reductive pathway possible	○	○	0	(0 3)
Methane*	<0.5 mg/L	VC oxidizes	●	○	0	
	>0.5 mg/L	Ultimate reductive daughter product, VC Accumulates	○	●	0	
Oxidation Reduction Potential* (ORP)	<50 millivolts (mV)	Reductive pathway possible	○	●	0	
	<-100mV	Reductive pathway likely	○	●	0	
pH*	5 < pH < 9	Optimal range for reductive pathway	●	○	0	
	5 > pH >9	Outside optimal range for reductive pathway	○	●	0	
TOC	>20 mg/L	Carbon and energy source; drives dechlorination, can be natural or anthropogenic	●	○	2	
Temperature*	>20°C	At T >20°C biochemical process is accelerated	○	●	0	
Carbon Dioxide	>2x background	Ultimate oxidative daughter product	○	○	0	(0-1)
Alkalinity	>2x background	Results from interaction of carbon dioxide with aquifer minerals	○	●	0	
Chloride*	>2x background	Daughter product of organic chlorine	○	●	0	
Hydrogen	>1 nM	Reductive pathway possible, VC may accumulate	○	○	0	(0 3)
	<1 nM	VC oxidized	○	○	0	
Volatile Fatty Acids	>0.1 mg/L	Intermediates resulting from biodegradation of aromatic compounds; carbon and energy source	○	●	0	
BTEX*	>0.1 mg/L	Carbon and energy source: drives dechlorination	○	●	0	
PCE*		Material released	●	○	0	
TCE*		Material released	●	○	0	
		Daughter product of PCE a/	●	○	2	
DCE*		Material released	○	●	0	
		Daughter product of TCE. If cis is greater than 80% of total DCE it is likely a daughter product of TCE a/, 1,1-DCE can be a chem. reaction product of TCA	●	○	2	
VC*		Material released	○	●	0	
		Daughter product of DCE a/	●	○	2	
1,1,1-Trichloroethane*		Material released	●	○	0	
DCA		Daughter product of TCA under reducing conditions	●	○	2	
Carbon Tetrachloride		Material released	○	●	0	
Chloroethane*		Daughter product of DCA or VC under reducing conditions	●	○	0	
Ethene/Ethane	>0.01 mg/L	Daughter product of VC/ethene	○	●	0	
	>0.1 mg/L	Daughter product of VC/ethene	○	●	3	
Chloroform		Material released	○	●	0	
		Daughter product of Carbon Tetrachloride	●	○	0	
Dichloromethane		Material released	○	●	0	
		Daughter product of Chloroform	○	●	0	

* required analyses

a/ Points awarded only if it can be shown that the compound is a daughter product (i.e., not a constituent of the source NAPL)

SCORE Reset

groundwater use restrictions would be implemented by NYSDEC or the municipality. Long-term groundwater monitoring and sampling are also readily accomplished.

12.2.2.7 ***Cost.*** Estimated capital and long-term O&M costs for Alternative 2 are included in Table 12-3. The long-term costs include the operation and maintenance of the Bowling Green VOC treatment processes. These costs are based on the assumptions included in the description of the alternative provided in Chapter 11 and have a range of accuracy of -30 to +50%. Annual O&M costs are estimated on a 30-year implementation basis, and are based on a 5% discount rate (EPA 1988) to estimate the present worth cost. Capital costs include monitoring well installation, along with legal and administrative costs associated with implementing institutional measures (the costs of which would be determined in the future depending on the way the institutional measures are implemented).

12.2.3 Alternative 3: Monitoring, Assessment, and Contingent Remediation

12.2.3.1 ***Protection of Human Health and the Environment.*** Institutional measures included in Alternative 3 serve to protect human health by preventing human contact with the contaminants that will remain in the off-site groundwater. While the potential for human exposure to the contaminants in the groundwater will remain, treatment of groundwater (i.e., air stripping and GAC adsorption) by the Bowling Green Water District prior to distribution into the public water supply system prevents exposure to groundwater contaminants. However, the off-site contamination may continue to impact the surrounding environment through the migration of VOCs through the groundwater. Long-term groundwater monitoring, as included in this alternative, is not protective of human health and the environment, but will assess any migration of the contaminant plume over time to document the nature of any continued risk posed by the contamination.

12.2.3.2 ***Compliance With SCGs.*** Since this alternative does not include an active remedial measure, it is highly unlikely that NYSDEC Class GA groundwater standards will be achieved in a short time frame. However, a technical evaluation of off-site groundwater monitoring data and remedial options will be performed annually. Based on the findings from the evaluation of the groundwater data, the monitoring program will be continued, discontinued, or amended as to number of wells and frequencies of monitoring. Based on the findings from the remedial options assessment, decisions will also be made as to the implementation of active groundwater remediation (i.e., Alternative 5A).

COST ESTIMATE FOR ALTERNATIVE 2: MONITORED NATURAL ATTENUATION

NCIA Off-Site Groundwater

ITEM	UNIT COST ($)[a]		QUANTITY	COST (2000 $)[b]	Present Worth Cost
CAPITAL COSTS					
A. Direct Costs					
Site Characterization					
Pilot Study includes MNA site conceptual model development, and additional characterization sampling	LS			$25,000	
Aquifer Pump Test (including treatment)	LS			$70,000	
Installation of Monitoring Well Couplets					
Intermediate/deep well couplets (70 and 200 ft bgs)	$15,000	/couplet	3 couplets	$45,000	
Intermediate/deep well couplets (100 and 250 ft bgs)	$21,000	/couplet	3 couplets	$63,000	
Institutional Measures					
Development restrictions				-[c]	
Groundwater use restrictions				-[c]	
			Subtotal	$203,000	
B. Indirect Costs					
Engineering and Design @ 15%				$30,000	
Legal and Administrative @ 10%				$20,000	
Contingency @ 25%				$51,000	
			Total	$304,000	**$304,000**

COST ESTIMATE FOR ALTERNATIVE 2: MONITORED NATURAL ATTENUATION

NCIA Off-Site Groundwater

ITEM	UNIT COST ($)[a]	QUANTITY	COST (2000 $)[b]	PRESENT WORTH COST
O&M COSTS				
Years 1-5				
Natural Attenuation Monitoring				
Quarterly sampling of 14 wells	$450 /well			
includes data and model evaluation		Annual Cost year 1 (56 wells):	$25,000 /yr	
Contaminant Plume Monitoring	$500 /well			
Semiannual sampling of 28 wells for VOCs		Annual Cost year 1 (56 wells):	$28,000 /yr	
			$53,000 /yr	**$229,000**
Years 6-30				
Natural Attenuation Monitroing				
Annual sampling of 14 wells	$450 /well			
includes data and model evaluation		Annual Cost year 6 (14 wells):	$6,000 /yr	
Contaminant Plume Monitoring	$500 /well			
Annual sampling of 28 wells for VOCs		Annual Cost year 6 (28 wells):	$14,000 /yr	
			$20,000 /yr	**$221,000**
Replacement of 3 wells every five years[d]	$18,000 /well			
(years 1 - 30)		Annual Cost year 1:	$11,000 /yr	**$169,000**
Operation and maintenance of Bowling Green VOC treatment processes[e]				
		Annual O&M Cost for year 2000:	$83,000 /yr	
		Replacement of air stripping tower after year 20:	$200,000	
				$1,476,000
PRESENT WORTH				
Based on 30-year alternative time frame				***$2,399,000***
and a 5% discount rate.				
				SAY $2.4 Million

a - Unit costs are for year 2000.
b - Costs rounded to the nearest $1000.
c - Legal and administrative costs to community that are not included in this cost estimate.
d - Cost assumes replacement of wells no greater than 250 ft in depth. It is assumed that the deep EW well will not be replaced under the MNA program described in this FS.
e - Refer to Alternative 1 (Table 12-2) for itemized Bowling Green O&M costs.
LS - Lump sum.

12.2.3.3 ***Reduction of Toxicity, Mobility, and Volume Through Treatment.*** Alternative 3 will not result in a substantial reduction in the toxicity, mobility, or volume of the contaminated groundwater. The groundwater monitoring program will, however, identify any reduction in contaminant concentrations that may occur, and may be used in decisions to implement an active remedy.

12.2.3.4 ***Short-Term Effectiveness.*** Alternative 3 will result in minimal short-term human or environmental impacts as the only activities that will occur include monitoring well installation and sampling of existing and new wells. As sampling has already been accomplished at the off-site area without causing negative short-term effects, sampling conducted in the future is not expected to have adverse impacts.

12.2.3.5 ***Long-Term Effectiveness and Permanence.*** Alternative 3 does not provide a high degree of long-term effectiveness and permanence, hence environmental degradation may continue to occur due to the migration of contaminants. Although human health risks may be mitigated through the use of development and groundwater use restrictions, these institutional measures may not eliminate the potential for human exposure to groundwater contaminants in downgradient areas. However, continued treatment of the groundwater supply for potable purposes (as is currently done) will minimize the potential for human exposure to NCIA off-site groundwater contaminants.

12.2.3.6 ***Implementability.*** Implementation of this alternative is straightforward and should not depend on the availability of vendors, materials, or services. Development and groundwater use restrictions would be implemented by NYSDEC or the municipality. Long-term groundwater monitoring and sampling are also readily accomplished.

12.2.3.7 ***Cost.*** For Alternative 3, capital costs include the installation of new monitoring wells, an annual technical analysis of groundwater data and remedial options (considered over the first five years of the alternative), and legal and administrative costs associated with implementing institutional measures (the costs of which would be determined in the future depending on how the institutional measures are implemented). Estimated long-term O&M costs, including the operation and maintenance of the Bowling Green VOC treatment processes, are included in Table 12-4. These costs are based on the assumptions included in the description of the alternative provided in Chapter 11 and have a range of accuracy of -30 to +50%. Annual O&M costs are estimated on a 30-year implementation basis and based on a 5% discount rate (EPA 1988) to estimate the present worth cost.

TABLE 12-4

COST ESTIMATE FOR ALTERNATIVE 3: MONITORING, ASSESSMENT, AND CONTINGENT REMEDIATION

NCIA Off-Site Groundwater

ITEM	UNIT COST ($)[a]	QUANTITY	COST (2000 $)[b]	Present Worth cost
CAPITAL COSTS				
A. Direct Costs				
Institutional Measures				
Development restrictions			-[c]	
Groundwater use restrictions			-[c]	
Installation of Monitoring Wells				
Intermediate/deep well couplets (70 and 200 ft bgs)	$15,000 /couplet	3 couplets	$45,000	
Intermediate/deep well couplets (100 and 250 ft bgs)	$21,000 /couplet	3 couplets	$63,000	
		Subtotal	$108,000	
B. Indirect Costs				
Engineering and Design (15%)			$16,000	
Legal and Administrative (10%)			$11,000	
Contingency (25%)			$27,000	
		Total	**$162,000**	**$162,000**
O&M COSTS				
Long-term groundwater monitoring program				
Semiannual sampling of 28 wells for VOCs for first 5 years	$500 /well	Annual Cost for year 1 (56 wells):	$28,000 /yr	
Periodic data maintenance and technical review of monitoring data and remedial options (years 1 - 5)	$30,000 /year	Annual Cost for year 1:	$30,000 /yr	
				$251,000
Annual sampling of 28 wells for VOCs for years 6 through 30	$500 /well	Annual Cost for year 6 (28 wells):	$14,000 /yr	
				$155,000
Replacement of 3 wells every 5 years (years 1-30)	$18,000 /well	Annual Cost for year 1:	$11,000 /yr	
				$169,000
Operation and maintenance of Bowling Green VOC treatment processes[d]				
		Annual Cost year 2000:	$83,000 /yr	
		Replacement of air stripping tower after year 20:	$200,000	
				$1,476,000
PRESENT WORTH				
Based on a 30-yr life and a 5% discount rate				***$2,213,000***
				SAY $2.2 million

a - Unit costs are for year 2000

b - Costs rounded to the nearest $1,000

c - Legal and administrative costs to community that are not included in cost estimate.

d - Refer to Alternative 1 (Table 12-2) for itemized Bowling Green O&M costs.

LS - Lump sum.

12.2.4 **Alternatives 4A and 5A: Remediation to Designated Depths with In-Well Vapor Stripping/Vapor Treatment**

Alternatives 4A and 5A employ in-well vapor stripping to address the off-site groundwater contamination. Alternative 4A includes the in-situ volatilization of groundwater contaminants in the upper portion of the aquifer (located at approximately 55 to 125 ft bgs) using in-well vapor stripping technology. "Hot spot" areas of contamination are targeted in Alternative 4A. Alternative 5A also addresses "hot spot" areas within the off-site groundwater, but targets contamination in the upper and deep portions of the aquifer (located at depths to 200 ft bgs). For each of these in-well vapor stripping alternatives, extracted vapor is treated at the surface using vapor phase GAC. Natural attenuation is assumed under both of these alternatives to assist in achieving remedial objectives. The alternatives are described in Chapter 11. The alternatives employ local VOC treatment systems. This section provides an analysis of the in-well vapor stripping technology used in Alternatives 4A and 5A with respect to the first seven evaluation criteria. Table 12-1 provides a comparative evaluation of the in-well vapor stripping alternatives.

12.2.4.1 ***Protection of Human Health and the Environment.*** Alternatives 4A and 5A are protective of human health and the environment through the active reduction of contaminant levels in the groundwater and by controlling further spread of the contaminant plumes. However, only "hot spot" areas of contamination are addressed in these two alternatives.

Alternatives 4A and 5A provide treatment of the contaminated off-site groundwater, but target different depths of contamination. Alternative 4A addresses the upper portion of the aquifer (to a depth of 125 ft bgs), and Alternative 5A remediates the upper and deep portions of the aquifer (to a depth of 200 ft bgs). Both Alternative 4A and 5A address "hot spot" areas of off-site groundwater contamination, and rely on natural attenuation to help achieve remedial objectives. Since Alternative 5A addresses the upper and deep portions of the aquifer, it is the more protective of these two in-well vapor stripping alternatives.

12.2.4.2 ***Compliance With SCGs.*** Alternatives 4A and 5A are anticipated to achieve compliance with chemical-specific SCGs that apply to the respective treatment depths of the contaminated off-site groundwater over time. In addition, the water district is responsible for meeting drinking water standards before supplying its users with potable water.

There are no promulgated air quality standards for the COCs in the off-site groundwater under the NAAQS or NYAAQS. However, emissions from the vapor treatment systems should comply with the guidance values of NYS Air Guide 1 discussed in Chapter 7 of this report. The remedial activities included in these alternatives (i.e., installation of stripper wells, treatment of contaminated groundwater, natural attenuation) are not expected to generate any air emissions that would exceed the NIOSH IDLH levels, OSHA PELs, and ACGIH TLVs for contaminants in air. Air monitoring will be conducted during the remedial activities to ensure that all requirements are met. Any VOCs volatilized and extracted from the groundwater will be removed by GAC to control emissions to the atmosphere.

Alternatives 4A and 5A will comply with location-specific SCGs that regulate remediation construction projects overlying a sole source aquifer by the construction of a secondary spill containment system around any chemical storage areas to prevent spill migration.

Alternatives 4A and 5A also comply with Federal and state regulatory requirements, which state that the selected remedial alternative must attain a cleanup level that eliminates, reduces, or controls risks to human health and the environment. Under these alternatives, contaminants in groundwater will be addressed by active remediation and natural attenuation.

12.2.4.3 ***Reduction of Toxicity, Mobility, and Volume Through Treatment.*** Alternatives 4A and 5A will reduce the volume of contamination present by injecting air into the wells, volatilizing the VOCs in the groundwater, and extracting the volatilized contaminants for subsequent treatment. Extracting VOCs from the groundwater phase effectively reduces their toxicity, mobility, and volume in the underlying aquifer. The extracted VOCs will be adsorbed onto vapor phase GAC, where their mobility, volume, and toxicity will be reduced. Reductions in toxicity, mobility, and volume of VOCs will be the greater under Alternatives 5A (i.e., remediation to depth of 200 ft bgs).

12.2.4.4 ***Short-Term Effectiveness.*** The installation of in-well vapor stripping wells, air injection equipment, and localized vapor treatment vaults is expected to result in minimal impacts to human health or the environment. However, residential/institutional activities may temporarily be impacted during installation and startup, and slightly increased local traffic and noise are expected. Off-site locations (e.g., active roadways) will be temporarily impacted by the remedial activities due to treatment system installation. Minimal space is required under Alternatives 4A and 5A, as local treatment vaults (each with a ground surface footprint of approximately 150 ft^2) will be installed in the subsurface adjacent to each of the treatment wells.

12.2.4.5 ***Long-Term Effectiveness and Permanence.*** Alternatives 4A and 5A are intended, over time, to remove VOCs permanently from the contaminated off-site groundwater, at depths to 125 ft and 200 ft bgs, respectively. The estimated timeframes for operating the in-well vapor stripping systems, based on information obtained from experienced vendors of the in-well vapor stripping technology, is about seven years for Alternative 4A and nine years for Alternative 5A, as described in Chapter 11. Both alternatives assume an overall project life of 20 years, as several years of natural attenuation (13 years under Alternative 4A and 11 years under Alternative 5A) are assumed to be required subsequent to the active treatment in order to achieve the remedial objectives. The long-term effectiveness of these alternatives will be optimized by assessing aquifer characteristics, appropriate design of the air delivery and vapor extraction systems, and the rate of chemical reaction and desorption of the VOC contaminants from aquifer soil particles as required prior to volatilization of the contaminants from the groundwater. The actual timeframes for the Alternative 4A and 5A remedial actions may actually be longer if the existing site conditions prove to be less than ideal. Once the in-well vapor stripping system is operational, performance will be monitored through periodic vapor and groundwater monitoring. Pilot tests of this technology would lead to better estimates of the required remedial timeframes. Continued treatment of the groundwater supply for potable purposes (as is currently done) will also minimize the potential for human exposure to NCIA off-site groundwater contaminants.

12.2.4.6 ***Implementability.*** Installation of the in-well vapor stripping wells and equipment can be achieved in the off-site area; however, a limited number of vendors are available that are licensed to construct and operate the in-well vapor stripping technology. The vapor treatment system recommended in these alternatives is a commonly applied technology that is readily implementable. However, potential negative public perceptions concerning placement of the remediation system along with local permits that would be required will need to be addressed.

12.2.4.7 ***Cost.*** Estimated capital and long-term O&M costs for Alternatives 4A and 5A are included in Tables 12-5 and 12-6, respectively. Long-term costs for these alternatives include the operation and maintenance of the Bowling Green VOC treatment processes. These costs are based on the assumptions included in the description of the alternatives provided in Chapter 11 and have a range of accuracy of -30 to +50%. Annual O&M costs are estimated on the project life assumed for each alternative and based on a 5% discount rate (EPA 1988) to estimate the present worth cost.

In deriving cost estimates for Alternatives 4A and 5A, installation of UVB in-well vapor stripping systems was assumed. Costs for several line items were obtained from a vendor familiar with UVB installation and operation and maintenance issues. Being that in-well vapor stripping is an innovative technology at hazardous waste sites and is still being optimized, capital costs for the system are fairly high. Like many innovative technologies, costs decrease with successive applications. Capital costs for the in-well vapor stripping technology vary widely; therefore, the cost estimates presented in Chapter 12 (Tables 12-5 and 12-6) may decrease substantially if quotes are obtained for in-well vapor stripping technologies other than the UVB system. Appendix K provides a brief sensitivity analysis that was performed for an alternative (DDC) in-well vapor stripping system.

12.2.5 Alternatives 4B and 5B: Remediation to Designated Depths with Groundwater Extraction/Air Stripping/Vapor Treatment /Reinjection

Alternatives 4B and 5B employ groundwater extraction/air stripping ("pump and treat") to address the off-site groundwater contamination. Both alternatives are described in Chapter 11. Alternative 4B addresses the upper portion of the off-site groundwater contamination (to a depth of 125 ft bgs); Alternative 5B remediates the upper and deep portions of the aquifer (to a depth of 200 ft bgs). "Hot spot" areas of contamination are targeted in Alternatives 4B and 5B. Both alternatives also employ natural attenuation to assist in achieving remedial objectives. Centralized VOC treatment is assumed for these pump and treat alternatives. This section provides an analysis of the pump and treat technology used in both Alternatives 4B and 5B with respect to the first seven evaluation criteria. Table 12-1 provides a comparative evaluation of the groundwater extraction/air stripping alternatives.

12.2.5.1 ***Protection of Human Health and the Environment.*** Alternatives 4B and 5B include the extraction of contaminated groundwater from the underlying aquifers and

COST ESTIMATE FOR ALTERNATIVE 4A: IN-WELL VAPOR STRIPPING/VAPOR TREATMENT LOCALIZED DELIVERY AND VAPOR TREATMENT UPPER AQUIFER REMEDIATION (TO 125 FT BGS)

New Cassel Industrial Area Off-site Groundwater

ITEM	UNIT COST ($)[a]		QUANTITY	COST (2000 $)[b]	Present Worth Cost
CAPITAL COSTS					
A. Direct Costs					
Pilot Test	LS			$105,000	
Site Preparation					
Contractor mobilization/demobilization	LS			$29,000	
Installation of Monitoring Wells					
Intermediate/deep well couplets (70 and 200 ft bgs)	$15,000	/couplet	3 couplets	$45,000	
Intermediate/deep well couplets (100 and 250 ft bgs)	$21,000	/couplet	3 couplets	$63,000	
Well/Remediation System Installation/Start-up					
Stripping Wells includes electrical components/controls	$68,000	/well	4 wells	$272,000	
Phone Line and Auto Dialer	$700	/unit	4 units	$3,000	
Condensate Storage Container	$640	/unit	4 units	$3,000	
Soil Disposal (nonhazardous)	$110	/cy	210 cy	$23,000	
Vapor Treatment GAC Installation	LS			$15,000	
			Subtotal	$558,000	
B. Indirect Costs					
Engineering and Design @ 15%				$84,000	
Legal and Administrative @ 10%				$56,000	
Contingency @ 25%				$140,000	
			Total	$838,000	**$838,000**

COST ESTIMATE FOR ALTERNATIVE 4A: IN-WELL VAPOR STRIPPING/VAPOR TREATMENT LOCALIZED DELIVERY AND VAPOR TREATMENT UPPER AQUIFER REMEDIATION (TO 125 FT BGS)

New Cassel Industrial Area Off-site Groundwater

ITEM	UNIT COST ($)[a]		QUANTITY	COST (2000 $)[b]	Present Worth Cost
O&M COSTS					
Part-time Operator Attention (years 1-7)	$35,000	/yr			
			Annual cost for year 1:	$35,000 /yr	$203,000
Condensate Control (years 1-7)	$3.00	/gal	6,000 gallons		
			Annual cost for year 1 (860 gallons):	$3,000 /yr	$17,000
GAC maintenance					
Year 1	$2.05	/lb	7,900 lb		
			Annual cost for year 1:	$16,000 /yr	$16,000
Year 2 - 7	$2.05	/lb	23,700 lb		
			Annual cost for year 2 (assume 4000 lb GAC):	$8,000 /yr	$39,000
Vapor Monitoring					
Year 1: samp emission (once per 2 mo)	$3,500	/event	6 events		
			Annual cost for year 1:	$21,000 /yr	$21,000
Year 2-7: samp emission (twice per year)	$3,500	/event	12 events		
			Annual cost for year 2:	$7,000 /yr	$34,000
Long-term groundwater monitoring program					
Years 1-2: Quarterly, 28 wells, VOCs	$500	/well	224 wells		
			Annual cost for year 1 (112 wells):	$56,000 /yr	$104,000
Years 3-20: Annual, 28 wells, VOC's	$500	/well	504 wells		
			Annual cost for year 3 (28 wells):	$14,000 /yr	$148,000
Repair/replacement of equipment					
General @ 5% per year (years 1-7)	$5,000	/yr	7 yrs		
			Annual cost for year 1:	$5,000 /yr	$29,000
Replacement of 3 wells every 5 years (years 1-20)	$18,000	/well			
			Annual cost for year 1:	$11,000 /yr	$127,000
Electricity (years 1-7)	$0.10	/kw-hr	2,146,200 kw-hr		
			Annual cost for year 1:	$31,000 /yr	$179,000
Operation and maintenance of Bowling Green VOC treatment processes[c]					
			Annual cost for year 2000:	$83,000	$1,034,000
PRESENT WORTH					
Based on 7 years of operation, 20 years of groundwater monitoring, and a 5% discount rate.					***$2,799,000***
					SAY $2.8 Million

a - Unit costs are for year 2000
b - Costs rounded to the nearest $1000.
c - Refer to Alternative 1 (Table 12-2) for itemized Bowling Green O&M costs. Cost includes GAC vessel O&M (including vessel replacement at year 10), air stripper O&M, control/electrical system O&M, electricity, and administrative costs over 20 year period. Cost does not include replacement of air stripping tower
LS - Lump sum

COST ESTIMATE FOR ALTERNATIVE 5A: IN-WELL VAPOR STRIPPING/VAPOR TREATMENT LOCALIZED DELIVERY AND VAPOR TREATMENT INTERMEDIATE/DEEP AQUIFER REMEDIATION (TO 200 FT BGS)

New Cassel Industrial Area Off-site Groundwater

ITEM	UNIT COST ($)[a]		QUANTITY	COST (2000 $)[b]	Present Worth Cost
CAPITAL COSTS					
A. Direct Costs					
Pilot Test	LS			$105,000	
Site Preparation					
Contractor mobilization/demobilization	LS			$39,000	
Installation of Monitoring Wells					
Intermediate/deep well couplets (70 and 200 ft bgs)	$15,000	/couplet	3 couplets	$45,000	
Intermediate/deep well couplets (100 and 250 ft bgs)	$21,000	/couplet	3 couplets	$63,000	
Well/Remediation System Installation/Start-up					
Stripping Wells includes electrical components/controls	$75,000	/well	6 wells	$450,000	
Phone Line and Auto Dialer	$700	/unit	6 units	$4,000	
Condensate Storage Container	$635	/unit	6 units	$4,000	
Soil Disposal (nonhazardous)	$110	/cy	310 cy	$34,000	
Vapor Treatment GAC Installation	LS			$32,000	
			Subtotal	$776,000	
B. Indirect Costs					
Engineering and Design @ 15%				$116,000	
Legal and Administrative @ 10%				$78,000	
Contingency @ 25%				$194,000	
			Total	$1,164,000	**$1,164,000**

COST ESTIMATE FOR ALTERNATIVE 5A: IN-WELL VAPOR STRIPPING/VAPOR TREATMENT LOCALIZED DELIVERY AND VAPOR TREATMENT INTERMEDIATE/DEEP AQUIFER REMEDIATION (TO 200 FT BGS)

New Cassel Industrial Area Off-site Groundwater

ITEM	UNIT COST ($)[a]		QUANTITY	COST (2000 $)[b]	Present Worth Cost
O&M COSTS					
Half-time Operator Attention (years 1-9)	$50,000	/yr			
			Annual cost for year 1:	$50,000 /yr	$355,000
Condensate Control (years 1-9)	$3.00	/gal	16,400 gal		
			Annual cost for year 1 (assume 1800 gallons):	$5,000 /yr	$36,000
GAC maintenance					
Year 1	$2.05	/lb	15,800 lb		
			Annual cost for year 1:	$32,000 /yr	$32,000
Year 2 - 9	$2.05	/lb	62,900 lb		
			Annual cost for year 2 (assume 7900 lb GAC):	$16,000 /yr	$98,000
Vapor Monitoring					
Year 1: samp emission (once per 2 mo)	$3,500	/event	6 events		
			Annual cost for year 1:	$21,000 /yr	$21,000
Year 2-9: samp emission (twice per year)	$3,500	/event	16 events		
			Annual cost for year 2:	$7,000 /yr	$43,000
Long-term groundwater monitoring program					
Years 1-2: Quarterly, 28 wells, VOCs	$500	/well	224 wells		
			Annual cost for year 1 (112 wells):	$56,000 /yr	$104,000
Years 3-20: Annual, 28 wells, VOC's	$500	/well	504 wells		
			Annual cost for year 3 (28 wells):	$14,000 /yr	$148,000
Repair/replacement of equipment					
General @ 5% per year (years 1-9)	$8,000	/yr	9 yrs		
			Annual cost for year 1:	$8,000 /yr	$57,000
Replacement of 3 wells every 5 years (years 1-20)	$18,000	/well			
			Annual cost for year 1:	$11,000 /yr	$137,000
Electricity (years 1-9)	$0.10	/kw-hr	4,139,100 kw-hr		
			Annual cost for year 1:	$46,000 /yr	$327,000
Operation and maintenance of Bowling Green VOC treatment processes[c]					
			Annual cost for year 2000:	$83,000 /yr	$1,034,000
PRESENT WORTH					
Based on 9 years of operation, 20 years of groundwater monitoring, and a 5% discount rate.					***$3,556,000***
					SAY $3.6 Million

a - Unit costs are for year 2000.
b - Costs rounded to the nearest $1000.
c - Refer to Alternative 1 (Table 12-2) for itemized Bowling Green O&M costs. Cost includes GAC vessel O&M (including vessel replacement at year 10), air stripper O&M, control/electrical system O&M, electricity, and administrative costs over 20 year period. Cost does not include replacement of air stripping tower.
LS - Lump sum.

treatment at the surface to remove VOC contaminants. In the treatment process (air stripping), VOCs are transferred from the water to the vapor phase, then adsorbed onto GAC. The treated effluent is returned to the subsurface via underground injection wells (wet wells). Alternatives 4B and 5B are protective of human health and the environment because they reduce contaminant levels in the groundwater and control further migration of the contaminant plumes. However, only "hot spot" areas of contamination are addressed in these two alternatives.

Alternatives 4B and 5B provide treatment of the contaminated off-site groundwater, but target different depths of contamination. Alternative 4B addresses the upper portion of the aquifer, and Alternative 5B remediates the upper and deep portions of the aquifer. Both Alternative 4B and 5B address "hot spot" areas of off-site groundwater contamination, and rely on natural attenuation to help achieve remedial objectives. Since Alternative 5B addresses the upper and deep portions of the aquifer, it is the more protective of these two pump and treat alternatives.

12.2.5.2 ***Compliance With SCGs.*** Alternatives 4B and 5B are anticipated to achieve compliance with chemical-specific SCGs that apply to the respective treatment depths of the contaminated off-site groundwater over time. Treated effluent from the Alternative 4B and 5B groundwater treatment systems will meet all applicable groundwater effluent criteria prior to being discharged to nearby wet wells.

There are no promulgated air quality standards for the COCs in the off-site groundwater under the NAAQS or NYAAQS. However, emissions from the groundwater treatment plant should comply with the guidance values of NYS Air Guide 1 discussed in Chapter 7 of this report. The remedial activities included in these alternatives (i.e., installation of extraction wells, treatment of groundwater, natural attenuation) are not expected to generate any air emissions that would exceed the NIOSH IDLH levels, OSHA PELs, and ACGIH TLVs for contaminants in air. Air monitoring will be conducted during the remedial activities to ensure that these requirements are met. Any VOCs volatilized and extracted from the groundwater will be removed by GAC to control emissions to the atmosphere.

Alternatives 4B and 5B will comply with location-specific SCGs that regulate remediation construction projects overlying a sole source aquifer by constructing a secondary spill containment system around any chemical storage areas to prevent spill migration.

Alternatives 4B and 5B also comply with Federal and state regulatory requirements, which state that the selected remedial alternative must attain a cleanup level that eliminates, reduces, or controls risks to human health and the environment. Under these alternatives, contaminants in groundwater will be addressed by active remediation and natural attenuation.

12.2.5.3 ***Reduction of Toxicity, Mobility, and Volume Through Treatment.*** Alternatives 4B and 5B will reduce the toxicity, mobility, and volume of contaminants underlying the NCIA off-site area by extracting and treating the contaminated groundwater. VOCs will be stripped from the water phase and adsorbed onto vapor phase GAC, thereby reducing their mobility, volume, and toxicity in the environment. Reductions in toxicity, mobility, and volume of VOCs will be greater under Alternative 5B (i.e., remediation to a depth of 200 ft bgs).

12.2.5.4 ***Short-Term Effectiveness.*** The installation of pumping wells, a groundwater treatment system, and wet wells is expected to result in minimal impacts to human health or the environment. However, residential/institutional activities may temporarily be impacted during installation and startup, and slightly increased local traffic and noise are expected. Off-site locations (e.g., active roadways) will be temporarily impacted by the remedial activities due to trenching and treatment system installation. Under Alternatives 4B and 5B, central treatment structures will be constructed (approximate size of 3200 sf). It is estimated that approximately 3700 l.f. of roadway trenching will be required under both Alternatives 4B and 5B.

12.2.5.5 ***Long-Term Effectiveness and Permanence.*** Alternatives 4B and 5B are intended, over time, to remove VOCs permanently from the contaminated off-site groundwater, at depths to 125 ft and 200 ft bgs, respectively. The estimated timeframes for operating the pump and treat systems are about nine years for Alternative 4B and 12 years for Alternative 5B, as described in Chapter 11. Both alternatives assume an overall project life of 20 years, as several years of natural attenuation (11 years under Alternative 4B and 8 years under Alternative 5B) are assumed to be required subsequent to the active treatment in order to achieve the remedial objectives. The long-term effectiveness of these alternatives will be optimized by assessing aquifer characteristics, appropriate design of the pumping, treatment, and re-injection systems, and the rate of chemical reaction and desorption of the VOC contaminants from aquifer soil particles as required prior to treatment. The actual timeframes for the Alternative 4B and 5B remedial actions may actually be longer if the existing subsurface conditions prove to be less than ideal. Once the groundwater extraction/air stripping system is operational, performance will be monitored through periodic vapor and groundwater monitoring. Aquifer pump tests and pilot tests of this technology would lead to better estimates of the required remedial timeframes. Continued treatment of the groundwater supply for potable purposes (as is currently done) will also minimize the potential for human exposure to NCIA off-site groundwater contaminants.

12.2.5.6 ***Implementability.*** The technologies required for installing extraction and injection wells and constructing groundwater treatment systems are readily available. The vapor treatment system recommended in these alternatives is a commonly applied technology that is readily implementable. However, potential negative public perceptions concerning placement of the facilities along with local permits that would be required will need to be addressed. For Alternatives 4B and 5B, it is likely that land would need to be acquired for the construction of a treatment building and wet wells for groundwater re-injection.

12.2.5.7 ***Cost.*** Estimated capital and long-term O&M costs for Alternatives 4B and 5B are included in Tables 12-7 and 12-8. Long-term costs for these alternatives include the operation and maintenance of the Bowling Green VOC treatment processes. These costs are based on the assumptions included in the description of the alternatives provided in Chapter 11, and have a range of accuracy of -30 to +50%. Annual O&M costs are estimated on the project life assumed for each alternative and based on a 5% discount rate (EPA 1988) to estimate the present worth cost.

12.2.6 Alternatives 6A and 7A: Full Plume Remediation to Designated Depths with In-Well Vapor Stripping/Vapor Treatment

Alternatives 6A and 7A employ in-well vapor stripping as the active remediation technology to address the off-site groundwater contamination. Alternatives 6A and 7A remediate the aerial extent of the off-site groundwater contamination (to the designated depths) to Class GA groundwater standards. The upper portion of the aquifer (to a depth of 125 ft bgs) is addressed in Alternative 6A, and the upper and deep portions of the aquifer (to 200 ft bgs) are addressed in Alternative 7A. For each of these in-well vapor stripping alternatives, extracted vapor is treated at the surface using local vapor phase GAC treatment systems. Both of these alternatives are described in Chapter 11. This section

COST ESTIMATE FOR ALTERNATIVE 4B: GROUNDWATER EXTRACTION/AIRSTRIPPING/RE-INJECTION
(REMEDIATION OF AQUIFER TO 125 FT BGS)
New Cassel Industrial Area Off-Site

ITEM	UNIT COST ($) [a]		QUANTITY	COST (2000 $) [b]	Present Worth Cost
CAPITAL COSTS					
A. Direct Costs					
Treatability Study	LS			$20,000	
Aquifer Pump Test [1] (includes treatment)	$60,000		3	$180,000	
Site Preparation					
Contractor Mobilization/Demobilization	LS			$76,000	
Well Installation					
Drilling and Installation of 110-ft Extraction Well	$31,000	/well	3 wells	$93,000	
Disposal of Soil as Nonhazardous (110-ft well)	$110	/yd³	9.6 yd³	$1,000	
Drilling and Installation of 80-ft Extraction Well	$22,000	/well	1 wells	$22,000	
Disposal of Soil as Nonhazardous (80-ft well)	$110	/yd³	2.3 yd³	$1,000	
Pump, Transducer, Concrete Encasement	$5,000	/well	4 wells	$20,000	
Installation of Connection Piping					
Trenching, Bedding, Pipe, Conduit	$35.00	/lf	3,700 lf	$130,000	
Asphalt Removal, Disposal, Restoration	$42.74	/lf	3,700 lf	$158,000	
Groundwater Treatment					
Treatment System Equipment	LS		-	$352,000	
Air Stripper	$43,000	/unit	1 unit	$43,000	
Electrical Components and Controls	LS		-	$60,000	
Housing for Treatment Operations	LS		-	$208,000	
Infiltration Wells					
Wet Well (8-ft diameter, 15-ft deep)	$20,000	/ well	4 wells	$80,000	
Installation of Monitoring Wells					
Intermediate/deep well couplets (70 and 200 ft bgs)	$15,000	/couplet	3 couplets	$45,000	
Intermediate/deep well couplets (100 and 250 ft bgs)	$21,000	/couplet	3 couplets	$63,000	
			Subtotal:	$1,552,000	
B. Indirect Costs					
Engineering and Design (15%)				$233,000	
Legal and Administrative (10%)				$155,000	
Contingency (25%)				$388,000	
			Total:	$2,328,000	**$2,328,000**

COST ESTIMATE FOR ALTERNATIVE 4B: GROUNDWATER EXTRACTION/AIRSTRIPPING/RE-INJECTION

(REMEDIATION OF AQUIFER TO 125 FT BGS)

New Cassel Industrial Area Off-Site

ITEM	UNIT COST ($) [a]		QUANTITY	COST (2000 $) [b]		Present Worth Cost
O&M COSTS						
Electrical Usage (years 1 - 9)	$0.10	/kW-hr	1,655,640 kW-hr			
			Annual cost for year 1:	$18,000	/yr	$128,000
Chemical Usage (years 1 - 9)	$36,000	/year	9 years			
			Annual cost for year 1:	$36,000	/yr	$256,000
Sludge Disposal (Nonhazardous) (years 1-9)	$2.50	/gallon	1,980 gallon			
			Annual cost for year 1 (220 gallons):	$1,000	/yr	$7,000
Plant Operator (Half-Time)	$50,000	/year	9 years			
			Annual cost for year 1:	$50,000	/yr	$355,000
Vapor Phase GAC						
Carbon, first year	$2.05	/lb	9,250 lb			
			Annual cost for year 1:	$19,000	/yr	$19,000
Carbon (years 2 through 5)	$2.05	/lb	23,200 lb			
			Annual cost for year 2 (assume 5800 lb GAC):	$12,000	/yr	$41,000
Carbon (years 6 though 9)	$2.05	/lb	11,600 lb			
			Annual cost for year 6 (assume 2900 lb GAC):	$6,000	/yr	$17,000
System Monitoring '						
System Sampling (first year)	$500	/sample	152 samples			
System Sampling (years 2 through 9)	$500	/sample	160 samples			
			Annual cost for year 1:	$76,000	/yr	$76,000
			Annual cost for year 2:	$10,000	/yr	$62,000
Waste Characteristization of Sludge (first year)	LS			$1,500	/yr	$2,000
Air Monitoring (first year)	$1,000	/sample	6 samples			
Air Monitoring (years 2 through 9)	$1,000	/sample	16 samples			
			Annual cost for year 1:	$6,000	/yr	$6,000
			Annual cost for year 2:	$2,000	/yr	$12,000
Long-Term Groundwater Monitoring Program						
Quarterly sampling of 28 wells (years 1 to 2)	$500	/well	224 wells			
			Annual cost for year 1 (112 wells):	$56,000	/yr	$104,000
Annual sampling of 28 wells (years 3 to 20)	$500	/well	504 wells			
			Annual cost for year 3 (28 wells):	$14,000	/yr	$148,000
Replacement of 3 wells every 5 years	$18,000	/well				
			Annual cost for year 1:	$11,000	/yr	$137,000
Repair/Replacement of Equipment/Well Development (years 1-9)						
(5% of all treatment equipment)	$23,000	/yr				
(10% of infiltration gallery)	$8,000	/yr				
			Annual cost for year 1:	$31,000	/yr	$220,000
Operation and maintenance of Bowling Green VOC treatment processes [c]						
			Annual cost for year 2000:	$83,000	/yr	$1,034,000
TOTAL PRESENT WORTH COST FOR ALTERNATIVE:						***$4,952,000***
Based on 9 years of operation, 20 years of groundwater monitoring, and a 5% discount rate.						**Say $5.0 Million**

a - Unit costs are for year 2000.
b - Costs rounded to the nearest $1000.
c - Refer to Alternative 1 (Table 12-2) for itemized Bowling Green O&M costs. Cost includes GAC vessel O&M (including vessel replacement at year 10), air stripper O&M, control/electrical system O&M, electricity, and administrative costs over 20 year period. Cost does not include replacement of air stripping tower.
LS - Lump sum.
1 - Includes one pilot test well.
2 - Includes system performance, groundwater monitoring of extraction wells, and air emissions testing.
- Possible land acquisition costs are not included in the cost estimate.

COST ESTIMATE FOR ALTERNATIVE 5B: GROUNDWATER EXTRACTION/AIRSTRIPPING/RE-INJECTION

(REMEDIATION OF AQUIFER TO 200 FT BGS)

New Cassel Industrial Area Off-Site

ITEM	UNIT COST ($) [a]		QUANTITY		COST (2000 $) [a]	Present Worth Cost
CAPITAL COSTS						
A. Direct Costs						
Treatability Study	LS				$20,000	
Aquifer Pump Test [1] (includes treatment)	$60,000		3		$180,000	
Site Preparation						
Contractor Mobilization/Demobilization	LS				$79,000	
Well Installation						
Drilling and Installation of 150-ft Extraction Well	$42,000	/well	3	wells	$126,000	
Disposal of Soil as Nonhazardous (150-ft well)	$110	/yd³	13.2	yd³	$1,000	
Drilling and Installation of 80-ft Extraction Well	$22,000	/well	1	wells	$22,000	
Disposal of Soil as Nonhazardous (80-ft well)	$110	/yd³	2.3	yd³	$1,000	
Pump, Transducer, Concrete Encasement	$5,000	/well	4	wells	$20,000	
Installation of Connection Piping						
Trenching, Bedding, Pipe, Conduit	$35.00	/lf	3,850	lf	$135,000	
Asphalt Removal, Disposal, Restoration	$42.74	/lf	3,850	lf	$165,000	
Groundwater Treatment						
Treatment System Equipment	LS		-		$352,000	
Air Stripper	$43,000	/unit	1	unit	$43,000	
Electrical Components and Controls	LS		-		$60,000	
Housing for Treatment Operations	LS		-		$208,000	
Infiltration Wells						
Wet Well (8-ft diameter, 15-ft deep)	$20,000	/ well	4	wells	$80,000	
Installation of Monitoring Wells						
Intermediate/deep well couplets (70 and 200 ft bgs)	$15,000	/couplet	3	couplets	$45,000	
Intermediate/deep well couplets (100 and 250 ft bgs)	$21,000	/couplet	3	couplets	$63,000	
				Subtotal:	$1,600,000	
B. Indirect Costs						
Engineering and Design (15%)					$240,000	
Legal and Administrative (10%)					$160,000	
Contingency (25%)					$400,000	
				Total:	$2,400,000	**$2,401,000**

COST ESTIMATE FOR ALTERNATIVE 5B: GROUNDWATER EXTRACTION/AIRSTRIPPING/RE-INJECTION

(REMEDIATION OF AQUIFER TO 200 FT BGS)

New Cassel Industrial Area Off-Site

ITEM	UNIT COST ($) [a]		QUANTITY	COST (2000 $) [b]		Present Worth Cost
O&M COSTS						
Electrical Usage (years 1 - 12)	$0.10	/kW-hr	2,207,520 kW-hr			
			Annual cost for year 1:	$18,000	/yr	$160,000
Chemical Usage (years 1 - 12)	$36,000	/year	12 years			
			Annual cost for year 1:	$36,000	/yr	$319,000
Sludge Disposal (Nonhazardous) (years 1-12)	$2.50	/gallon	2,640 gallon			
			Annual cost for year 1 (220 gallons):	$1,000	/yr	$9,000
Plant Operator (Half-Time)	$50,000	/year	12 years			
			Annual cost for year 1:	$50,000	/yr	$443,000
Vapor Phase GAC						
Carbon, first year	$2.05	/lb	10,000 lb			
			Annual cost for year 1:	$21,000	/yr	$21,000
Carbon (years 2 through 7)	$2.05	/lb	36,000 lb			
			Annual cost for year 2 (assume 6000 lb GAC):	$12,000	/yr	$58,000
Carbon (years 8 though 12)	$2.05	/lb	10,000 lb			
			Annual cost for year 8 (assume 2000 lb GAC):	$4,000	/yr	$12,000
System Monitoring [2]						
System Sampling (first year)	$500	/sample	152 samples			
System Sampling (years 2 through 12)	$500	/sample	220 samples			
			Annual cost for year 1:	$76,000	/yr	$76,000
			Annual cost for year 2:	$10,000	/yr	$79,000
Waste Characteristization of Sludge (first year)	LS			$1,500	/yr	$2,000
Air Monitoring (first year)	$1,000	/sample	6 samples			
Air Monitoring (years 2 through 12)	$1,000	/sample	22 samples			
			Annual cost for year 1:	$6,000	/yr	$6,000
			Annual cost for year 2:	$2,000	/yr	$16,000
Long-Term Groundwater Monitoring Program						
Quarterly sampling of 28 wells (years 1 to 2)	$500	/well	224 wells			
			Annual cost for year 1 (112 wells):	$56,000	/yr	$104,000
Annual sampling of 28 wells (years 3 to 20)	$500	/well	504 wells			
			Annual cost for year 3 (28 wells):	$14,000	/yr	$148,000
Replacement of 3 wells every 5 years	$18,000	/well				
			Annual cost for year 1:	$11,000	/yr	$137,000
Repair/Replacement of Equipment/Well Development (years 1-12)						
(5% of all treatment equipment)	$23,000	/yr				
(10% of infiltration gallery)	$8,000	/yr				
			Annual cost for year 1:	$31,000	/yr	$275,000
Operation and maintenance of Bowling Green VOC treatment processes [c]						
			Annual cost for year 2000:	$83,000	/yr	$1,034,000
TOTAL PRESENT WORTH COST FOR ALTERNATIVE:						***$5,300,000***
Based on 12 years of operation, 20 years of groundwater monitoring, and a 5% discount rate.						**Say $5.3 Million**

a - Unit costs are for year 2000.
b - Costs rounded to the nearest $1000.
c - Refer to Alternative 1 (Table 12-2) for itemized Bowling Green O&M costs. Cost includes GAC vessel O&M (including vessel replacement at year 10), air stripper O&M, control/electrical system O&M, electricity, and administrative costs over 20 year period. Cost does not include replacement of air stripping tower.
LS - Lump sum.
1 - Includes one pilot test well.
2 - Includes system performance, groundwater monitoring of extraction wells, and air emissions testing.
- Possible land acquisition costs are not included in the cost estimate.

provides an analysis of the in-well vapor stripping technology used in Alternatives 6A and 7A with respect to the first seven evaluation criteria. Table 12-1 provides a comparative evaluation of these in-well vapor stripping alternatives.

12.2.6.1 ***Protection of Human Health and the Environment.*** Alternatives 6A and 7A are protective of human health and the environment through the active reduction of contaminant levels in the groundwater and by controlling further spread of the contaminant plumes.

Alternatives 6A and 7A provide full-scale treatment (i.e., NYS Class GA standards are achieved) of the contaminated off-site groundwater to the depths designated in each alternative. Alternative 6A addresses the upper portion of the aquifer (to a depth of 125 ft bgs), and Alternative 7A remediates the upper and deep portions of the aquifer (to a depth of 200 ft bgs). Thus, Alternative 7A is the most protective in-well vapor stripping alternative.

12.2.6.2 ***Compliance With SCGs.*** Alternatives 6A and 7A will achieve compliance with chemical-specific SCGs that apply to the respective treatment depths of the contaminated off-site groundwater, including Class GA groundwater standards, over varying time periods. Active remedial activities under these treatment scenarios will be continued until the Class GA standards are met. Long-term groundwater monitoring is assumed to be carried out for a total of twenty years under these two in-well vapor stripping alternatives to assure that SCGs are being met at deeper depths (i.e., via natural attenuation).

There are no promulgated air quality standards for the COCs in the off-site groundwater under the NAAQS or NYAAQS. However, emissions from the vapor treatment systems should comply with the guidance values of NYS Air Guide 1 discussed in Chapter 7 of this report. The remedial activities included in these alternatives (i.e., installation of stripper wells and the treatment of contaminated groundwater) are not expected to generate any air emissions that would exceed the NIOSH IDLH levels, OSHA PELs, and ACGIH TLVs for contaminants in air. Air monitoring will be conducted during the remedial activities to ensure that all requirements are met. Any VOCs volatilized and extracted from the groundwater will be removed by GAC to control emissions to the atmosphere.

Alternatives 6A and 7A will comply with location-specific SCGs that regulate remediation construction projects overlying a sole source aquifer by the construction of a secondary spill containment system around any chemical storage areas to prevent spill migration.

Alternatives 6A and 7A also comply with Federal and state regulatory requirements, which state that the selected remedial alternative must attain a cleanup level that eliminates, reduces, or controls risks to human health and the environment. Under this alternative, contaminants in groundwater will be removed and then treated at the surface.

12.2.6.3 ***Reduction of Toxicity, Mobility, and Volume Through Treatment.*** Alternatives 6A and 7A will reduce the volume of contamination present by injecting air into the wells, volatilizing the VOCs in the groundwater, and extracting the volatilized contaminants for subsequent treatment. Extracting VOCs from the groundwater phase effectively reduces their toxicity, mobility, and volume in the underlying aquifer. The extracted VOCs will be adsorbed onto vapor phase GAC, where their mobility, volume, and toxicity will be reduced. Reductions in toxicity, mobility, and volume of VOCs will be the greatest under Alternatives 7A (i.e., remediation to depth of 200 ft bgs).

12.2.6.4 ***Short-Term Effectiveness.*** The installation of in-well vapor stripping wells, air injection equipment, and localized vapor treatment vaults is expected to result in minimal impacts to human health or the environment. However, residential/institutional activities may temporarily be impacted during installation and startup, and slightly increased local traffic and noise are expected. Off-site locations (e.g., active roadways) will be temporarily impacted by the remedial activities due to treatment system installation. Minimal space is required under Alternatives 6A and 7A, as local treatment vaults (each with a ground surface footprint of approximately 150 ft^2) will be installed in the subsurface adjacent to each of the treatment wells.

12.2.6.5 ***Long-Term Effectiveness and Permanence.*** Alternatives 6A and 7A are intended to remove VOCs permanently from the contaminated off-site groundwater, at depths to 125 ft and 200 ft bgs, respectively. The estimated timeframes for operating the in-well vapor stripping systems, based on information obtained from experienced vendors of the in-well vapor stripping technology, are about five years for Alternative 6A and seven years for Alternative 7A, as described in Chapter 11. The long-term effectiveness of these alternatives will be optimized by assessing aquifer characteristics, appropriate design of the air delivery and vapor extraction systems, and the rate of chemical reaction and desorption of the VOC contaminants from aquifer soil particles as required prior to volatilization of the contaminants from the groundwater. The actual timeframes for the Alternative 6A and 7A remedial actions may actually be longer if the existing site conditions prove to be less than ideal. Once the in-well vapor stripping system is operational, performance will be monitored through periodic vapor and groundwater monitoring. Pilot tests of this technology would lead to better estimates of the required remedial timeframes. Continued treatment of the groundwater supply for potable purposes (as is currently done) will also minimize the potential for human exposure to NCIA off-site groundwater contaminants. As stated above, a 20-year long-term groundwater monitoring program is assumed for both alternatives.

12.2.6.6 ***Implementability.*** Installation of the in-well vapor stripping wells and equipment can be achieved in the off-site area; however, a limited number of vendors are available that are licensed to construct and operate the in-well vapor stripping technology. The vapor treatment system recommended in these alternatives is a commonly applied technology that is readily implementable. However, potential negative public perceptions concerning placement of the remediation system along with local permits that would be required will need to be addressed.

12.2.6.7 ***Cost.*** Estimated capital and long-term O&M costs for Alternatives 6A and 7A are included in Tables 12-9 and 12-10, respectively. Long-term costs for these alternatives include the operation and maintenance of the Bowling Green VOC treatment processes. These costs are based on the assumptions included in the description of the alternatives provided in Chapter 11 and have a range of accuracy of -30 to +50%. Annual O&M costs are estimated on the project life assumed for each alternative and based on a 5% discount rate (EPA 1988) to estimate the present worth cost.

In deriving cost estimates for Alternatives 6A and 7A, installation of UVB in-well vapor stripping systems was assumed. Costs for several line items were obtained from a vendor familiar with UVB installation and operation and maintenance issues. Being that in-well vapor stripping is an innovative technology at hazardous waste sites and is still being optimized, capital costs for the system are fairly high. Like many innovative technologies, costs decrease with successive applications. Capital costs for the in-well vapor stripping technology vary widely; therefore, the cost estimates presented in Chapter 12 (Tables 12-9 and 12-10) may decrease substantially if quotes are obtained for in-well vapor stripping

COST ESTIMATE FOR ALTERNATIVE 6A: IN-WELL VAPOR STRIPPING/VAPOR TREATMENT LOCALIZED DELIVERY AND VAPOR TREATMENT FULL PLUME REMEDIATION - UPPER AQUIFER (TO 125 FT BGS)

New Cassel Industrial Area Off-site Groundwater

ITEM	UNIT COST ($)[a]		QUANTITY	COST (2000 $)[b]	Present Worth Cost
CAPITAL COSTS					
A. Direct Costs					
Pilot Test	LS			$105,000	
Site Preparation					
Contractor mobilization/demobilization	LS			$48,000	
Installation of Monitoring Wells					
Intermediate/deep well couplets (70 and 200 ft bgs)	$15,000	/couplet	3 couplets	$45,000	
Intermediate/deep well couplets (100 and 250 ft bgs)	$21,000	/couplet	3 couplets	$63,000	
Well/Remediation System Installation/Start-up					
Stripping Wells includes electrical components/controls	$68,000	/well	9 wells	$612,000	
Phone Line and Auto Dialer	$700	/unit	9 unit	$6,000	
Condensate Storage Container	$640	/unit	9 units	$6,000	
Soil Disposal (nonhazardous)	$110	/cy	470 cy	$52,000	
Vapor Treatment GAC Installation	LS			$19,000	
			Subtotal	$956,000	
B. Indirect Costs					
Engineering and Design @ 15%				$143,000	
Legal and Administrative @ 10%				$96,000	
Contingency @ 25%				$239,000	
			Total	$1,434,000	**$1,434,000**

Figure 22
Alternative 8
Full Plume Remediation of Upper and Deep Portions of the Aquifer to 225 ft bgs with In-Well Vapor Stripping/Localized Vapor Treatment
New Cassel Industrial Area

COST ESTIMATE FOR ALTERNATIVE 6A: IN-WELL VAPOR STRIPPING/VAPOR TREATMENT LOCALIZED DELIVERY AND VAPOR TREATMENT FULL PLUME REMEDIATION - UPPER AQUIFER (TO 125 FT BGS)

New Cassel Industrial Area Off-site Groundwater

ITEM	UNIT COST ($)[a]	QUANTITY	COST (2000 $)[b]	Present Worth Cost
O&M COSTS				
Full-time Operator Attention (years 1-5)	$75,000 /yr	5 yrs		
		Annual cost for year 1:	$75,000 /yr	$325,000
Condensate Control (years 1-5)	$3.00 /gal	7,300 gal		
		Annual cost for year 1 (assume 1460 gallons):	$4,000 /yr	$17,000
GAC maintenance				
Year 1	$2.05 /lb	14,600 lb		
		Annual cost for year 1:	$30,000 /yr	$30,000
Year 2 - 5	$2.05 /lb	29,100 lb		
		Annual cost for year 2 (assume 7300 lb GAC):	$15,000 /yr	$51,000
Vapor Monitoring				
Year 1: samp emission (once per 2 mo)	$3,500 /event	6 events		
		Annual cost for year 1:	$21,000 /yr	$21,000
Year 2-5: samp emission (twice per year)	$3,500 /event	8 events		
		Annual cost for year 2:	$7,000 /yr	$24,000
Long-term groundwater monitoring program				
Years 1-2: Quarterly, 28 wells, VOCs	$500 /well	224 wells		
		Annual cost for year 1 (112 wells):	$56,000 /yr	$104,000
Years 3-20: Annual, 28 wells, VOC's	$500 /well	504 wells		
		Annual cost for year 3 (28 wells):	$14,000 /yr	$148,000
Repair/replacement of equipment				
General @ 5% per year (years 1-5)	$11,000 /yr	5 yrs		
		Annual cost for year 1:	$11,000 /yr	$48,000
Replacement of 3 wells every 5 years (years 1-20)	$18,000 /well			
		Annual cost for year 1:	$11,000 /yr	$137,000
Electricity (years 1-5)	$0.10 /kw-hr	3,449,250 kw-hr		
		Annual cost for year 1:	$69,000 /yr	$299,000
Operation and maintenance of Bowling Green VOC treatment processes[c]				
		Annual cost for year 2000:	$83,000 /yr	$1,034,000
PRESENT WORTH				
Based on 5 years of operation, 20 years of groundwater monitoring, and a 5% discount rate.				***$3,672,000***
				SAY $3.7 Million

a - Unit costs are for year 2000.
b - Costs rounded to the nearest $1000.
c - Refer to Alternative 1 (Table 12-2) for itemized Bowling Green O&M costs. Cost includes GAC vessel O&M (including vessel replacement at year 10), air stripper O&M, control/electrical system O&M, electricity, and administrative costs over 20 year period. Cost does not include replacement of air stripping tower.
LS - Lump sum.

COST ESTIMATE FOR ALTERNATIVE 7A: IN-WELL VAPOR STRIPPING/VAPOR TREATMENT LOCALIZED DELIVERY AND VAPOR TREATMENT FULL PLUME REMEDIATION -INTERMEDIATE/DEEP AQUIFER (TO 200 FT BGS)

New Cassel Industrial Area Off-site Groundwater

ITEM	UNIT COST ($)[a]		QUANTITY	COST (2000 $)[b]	Present Worth Cost
CAPITAL COSTS					
A. Direct Costs					
Pilot Test	LS			$105,000	
Site Preparation					
Contractor mobilization/demobilization	LS			$69,000	
Installation of Monitoring Wells					
Intermediate/deep well couplets (70 and 200 ft bgs)	$15,000	/couplet	3 couplets	$45,000	
Intermediate/deep well couplets (100 and 250 ft bgs)	$21,000	/couplet	3 couplets	$63,000	
Well/Remediation System Installation/Start-up					
Stripping Wells includes electrical components/controls	$75,000	/well	13 wells	$975,000	
Phone Line and Auto Dialer	$700	/unit	13 unit	$9,000	
Condensate Storage Container	$635	/unit	13 units	$8,000	
Soil Disposal (nonhazardous)	$110	/cy	680 cy	$75,000	
Vapor Treatment GAC Installation	LS			$56,000	
			Subtotal	$1,405,000	
B. Indirect Costs					
Engineering and Design @ 15%				$211,000	
Legal and Administrative @ 10%				$141,000	
Contingency @ 25%				$351,000	
			Total	$2,108,000	**$2,108,000**

COST ESTIMATE FOR ALTERNATIVE 7A: IN-WELL VAPOR STRIPPING/VAPOR TREATMENT LOCALIZED DELIVERY AND VAPOR TREATMENT FULL PLUME REMEDIATION -INTERMEDIATE/DEEP AQUIFER (TO 200 FT BGS)

New Cassel Industrial Area Off-site Groundwater

ITEM	UNIT COST ($)[a]		QUANTITY	COST (2000 $)[b]	Present Worth Cost
O&M COSTS					
Full-time Operator Attention (years 1-7)	$75,000	/yr	7 yrs		
			Annual cost for year 1:	$75,000 /yr	$434,000
Condensate Control (years 1-7)	$3.00	/gal	21,300 gal		
			Annual cost for year 1 (assume 3040 gallons):	$9,000 /yr	$52,000
GAC maintenance					
Year 1	$2.05	/lb	27,600 lb		
			Annual cost for year 1:	$57,000 /yr	$57,000
Year 2 - 7	$2.05	/lb	82,800 lb		
			Annual cost for year 2 (assume 13800 lb GAC):	$28,000 /yr	$135,000
Vapor Monitoring					
Year 1: samp emission (once per 2 mo)	$3,500	/event	6 events		
			Annual cost for year 1:	$21,000 /yr	$21,000
Year 2-7: samp emission (twice per year)	$3,500	/event	12 events		
			Annual cost for year 2:	$7,000 /yr	$34,000
Long-term groundwater monitoring program					
Years 1-2: Quarterly, 28 wells, VOCs	$500	/well	224 wells		
			Annual cost for year 1 (112 wells):	$56,000 /yr	$104,000
Years 3-20: Annual, 28 wells, VOC's	$500	/well	504 wells		
			Annual cost for year 3 (28 wells):	$14,000 /yr	$148,000
Repair/replacement of equipment					
General @ 5% per year (years 1-7)	$17,000	/yr	7 yrs		
			Annual cost for year 1:	$17,000 /yr	$98,000
Replacement of 3 wells every 5 years (years 1-20)	$18,000	/well			
			Annual cost for year 1:	$11,000 /yr	$137,000
Electricity (years 1-7)	$0.10	/kw-hr	6,975,150 kw-hr		
			Annual cost for year 1:	$100,000 /yr	$579,000
Operation and maintenance of Bowling Green VOC treatment processes[c]					
			Annual cost for year 2000:	$83,000 /yr	$1,034,000
PRESENT WORTH					
Based on 7 years of operation, 20 years of groundwater monitoring, and a 5% discount rate					***$4,941,000***
					SAY $4.9 Million

a - Unit costs are for year 2000

b - Costs rounded to the nearest $1000

c - Refer to Alternative 1 (Table 12-2) for itemized Bowling Green O&M costs. Cost includes GAC vessel O&M (including vessel replacement at year 10), air stripper O&M, control/electrical system O&M, electricity, and administrative costs over 20 year period. Cost does not include replacement of air stripping tower.

LS - Lump sum.

technologies other than the UVB system. Appendix K provides a brief sensitivity analysis that was performed for an alternative (DDC) in-well vapor stripping system.

12.2.7 Alternatives 6B and 7B: Full Plume Remediation to Designated Depths with Groundwater Extraction/Air Stripping/Vapor Treatment /Reinjection

Alternatives 6B and 7B employ groundwater extraction/air stripping ("pump and treat") as the active remediation technology to address the aerial extent of the off-site groundwater contamination (to the designated depths) to achieve NYS Class GA groundwater standards. Both alternatives are described in Chapter 11. Alternative 6B addresses the upper portion of the off-site groundwater contamination (to a depth of 125 ft bgs); Alternative 7B remediates the upper and deep portions of the aquifer (to a depth of 200 ft bgs). Both alternatives employ centralized VOC treatment. This section provides an analysis of the pump and treat technology used in both Alternatives 6B and 7B with respect to the first seven evaluation criteria. Table 12-1 provides a comparative evaluation of the groundwater extraction/air stripping alternatives.

12.2.7.1 ***Protection of Human Health and the Environment.*** Alternatives 6B and 7B include the extraction of contaminated groundwater from the underlying aquifers and treatment at the surface to remove VOC contaminants. Alternatives 6B and 7B remediate the aerial extent of the off-site groundwater (to the designated depths) to Class GA groundwater standards. In the treatment process (air stripping), VOCs are transferred from the water to the vapor phase, then adsorbed onto GAC. The treated effluent is returned to the subsurface via underground injection wells (wet wells). Alternatives 6B and 7B are protective of human health and the environment because they reduce contaminant levels in the groundwater and control further migration of the contaminant plumes.

Alternatives 6B and 7B provide treatment of the contaminated off-site groundwater (i.e., NYS Class GA standards are achieved), but target different depths of contamination. Alternative 6B addresses the upper portion of the aquifer, and Alternative 7B remediates the upper and deep portions of the aquifer. Thus, Alternative 7B is the most protective groundwater extraction/air stripping alternative.

12.2.7.2 ***Compliance With SCGs.*** Alternatives 6B and 7B will achieve compliance with chemical-specific SCGs that apply to the respective treatment depths of the contaminated off-site groundwater, including Class GA groundwater standards, over varying time periods. Active remedial activities under the treatment scenarios of Alternatives 6B and 7B will be continued until the Class GA standards are met. Treated effluent from the Alternative 6B and 7B groundwater treatment systems will meet all applicable groundwater effluent criteria prior to being discharged to nearby wet wells. Long-term groundwater monitoring is assumed to be carried out for a total of twenty years under these two pump and treat alternatives to assure that SCGs are being met at deeper depths (i.e., via natural attenuation).

There are no promulgated air quality standards for the COCs in the off-site groundwater under the NAAQS or NYAAQS. However, emissions from the groundwater treatment plant should comply with the guidance values of NYS Air Guide 1 discussed in Chapter 7 of this report. The remedial activities included in these alternatives (i.e., installation of extraction wells and the treatment of groundwater) are not expected to generate any air emissions that would exceed the NIOSH IDLH levels, OSHA PELs, and ACGIH TLVs for contaminants in air. Air monitoring will be conducted during the remedial activities to ensure that these requirements are met. Any VOCs volatilized and extracted from the groundwater will be removed by GAC to control emissions to the atmosphere.

Alternatives 6B and 7B will comply with location-specific SCGs that regulate remediation construction projects overlying a sole source aquifer by constructing a secondary spill containment system around any chemical storage areas to prevent spill migration.

Alternatives 6B and 7B also comply with Federal and state regulatory requirements, which state that the selected remedial alternative must attain a cleanup level that eliminates, reduces, or controls risks to human health and the environment. Under these alternatives, contaminants in the NCIA off-site groundwater will be removed and treated at the surface.

12.2.7.3 ***Reduction of Toxicity, Mobility, and Volume Through Treatment.*** Alternatives 6B and 7B will reduce the toxicity, mobility, and volume of contaminants underlying the NCIA off-site area by extracting and treating the contaminated groundwater. VOCs will be stripped from the water phase and adsorbed onto vapor phase GAC, thereby reducing their mobility, volume, and toxicity in the environment. Reductions in toxicity, mobility, and volume of VOCs will be the greatest under Alternative 7B (i.e., remediation to a depth of 200 ft bgs).

12.2.7.4 ***Short-Term Effectiveness.*** The installation of pumping wells, a groundwater treatment system, and wet wells is expected to result in minimal impacts to human health or the environment. However, residential/institutional activities may temporarily be impacted during installation and startup, and slightly increased local traffic and noise are expected. Off-site locations (e.g., active roadways) will be temporarily impacted by the remedial activities due to trenching and treatment system installation. Under Alternatives 6B and 7B, an approximately 4000 ft^2 central treatment structure will be constructed. It is estimated that approximately 9400 l.f. and 10,300 l.f. of roadway trenching will be required under Alternatives 6B and 7B, respectively.

12.2.7.5 ***Long-Term Effectiveness and Permanence.*** Alternatives 6B and 7B are intended to remove VOCs permanently from the contaminated off-site groundwater, at depths to 125 ft and 200 ft bgs, respectively. The estimated timeframes for operating the pump and treat systems are about 7 years for Alternative 6B and 10 years for Alternative 7B, as described in Chapter 11. The long-term effectiveness of these alternatives will be optimized by assessing aquifer characteristics, appropriate design of the pumping, treatment, and re-injection systems, and the rate of chemical reaction and desorption of the VOC contaminants from aquifer soil particles as required prior to treatment. The actual timeframes for the Alternative 6B and 7B remedial actions may actually be longer if the existing subsurface conditions prove to be less than ideal. Once the groundwater extraction/air stripping system is operational, performance will be monitored through periodic vapor and groundwater monitoring. Aquifer pump tests and pilot tests of this technology would lead to better estimates of the required remedial timeframes. Continued treatment of the groundwater supply for potable purposes (as is currently done) will also minimize the potential for human exposure to NCIA off-site groundwater contaminants. As stated above, a 20-year long-term groundwater monitoring program is assumed for both alternatives.

12.2.7.6 ***Implementability.*** The technologies required for installing extraction and injection wells and constructing groundwater treatment systems are readily available. The vapor treatment system recommended in these alternatives is a commonly applied technology that is readily implementable. However, potential negative public perceptions concerning placement of the facilities along with local permits that would be required will need to be addressed. For Alternatives 6B and 7B, it is likely that land would need to be acquired for the construction of a treatment building and wet wells for groundwater re-injection.

12.2.7.7 ***Cost.*** Estimated capital and long-term O&M costs for Alternatives 6B and 7B are included in Tables 12-11 and 12-12. Long-term costs for these alternatives include the operation and maintenance of the Bowling Green VOC treatment processes. These costs are based on the assumptions included in the description of the alternatives provided in Chapter 11, and have a range of accuracy of -30 to +50%. Annual O&M costs are estimated on the project life assumed for each alternative and based on a 5% discount rate (EPA 1988) to estimate the present worth cost.

12.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

In the previous section, each of the remedial alternatives was individually evaluated with respect to the seven evaluation criteria. In this section, the comparative performance of the alternatives is discussed where common elements exist among them. Refer also to Table 12-1 for a comparative evaluation of the alternatives.

12.3.1 *Protection of Human Health and the Environment.*

Alternatives 1, 2, and 3 provide the least protection of human health and the environment as institutional controls will not be effective in preventing the migration of the contaminant plumes. Contaminants in the off-site groundwater may remain at concentrations above remedial objectives for several years under these alternatives. However, a thorough annual evaluation of monitoring data and remedial options will be performed in Alternative 3.

Of the active treatment remedies, Alternatives 4A and 4B (remediation of "hot spot" areas in the upper portion of the aquifers) provide similar levels of protection in that they each reduce levels of COCs in off-site groundwater to a depth of 125 ft bgs and control further downgradient migration of VOCs. Alternatives 4A and 4B also rely on natural attenuation to achieve remedial objectives for the groundwater contamination. Likewise, Alternatives 5A and 5B provide similar levels of protection to one another (i.e., remediation of "hot spot" areas in upper and deep portions of the off-site groundwater contamination, to a depth of 200 ft bgs). Alternatives 6A and 6B address groundwater contamination in the upper portion of the aquifer so that NYS Class GA standards are met. Alternatives 7A and 7B also achieve Class GA standards through active remediation, but target the upper and deep portions (to 200 ft bgs) of the aquifer. Thus, Alternative 7A or 7B provide the greatest

COST ESTIMATE FOR ALTERNATIVE 6B: GROUNDWATER EXTRACTION/AIRSTRIPPING/RE-INJECTION

(REMEDIATION OF AQUIFER TO 125 FT BGS)

New Cassel Industrial Area Off-Site

ITEM	UNIT COST ($) [a]		QUANTITY		COST (2000 $) [b]	Present Worth Cost
CAPITAL COSTS						
A. Direct Costs						
Treatability Study	LS				$20,000	
Aquifer Pump Test [1] (includes treatment)	$60,000		3		$180,000	
Site Preparation						
Contractor Mobilization/Demobilization	LS				$124,000	
Well Installation						
Drilling and Installation of 110-ft Extraction Well	$31,000	/well	11	wells	$341,000	
Disposal of Soil as Nonhazardous (110-ft well)	$110	/yd³	35.2	yd³	$4,000	
Drilling and Installation of 80-ft Extraction Well	$22,000	/well	1	wells	$22,000	
Disposal of Soil as Nonhazardous (80-ft well)	$110	/yd³	2.3	yd³	$1,000	
Pump, Transducer, Concrete Encasement	$5,000	/well	12	wells	$60,000	
Installation of Connection Piping						
Trenching, Bedding, Pipe, Conduit	$35.00	/lf	9,400	lf	$329,000	
Asphalt Removal, Disposal, Restoration	$42.74	/lf	9,400	lf	$402,000	
Groundwater Treatment						
Treatment System Equipment	LS		-		$453,000	
Air Stripper	$61,000	/unit	1	unit	$61,000	
Electrical Components and Controls	LS		-		$60,000	
Housing for Treatment Operations	LS		-		$260,000	
Infiltration Wells						
Wet Well (8-ft diameter, 15-ft deep)	$20,000	/ well	7	wells	$140,000	
Installation of Monitoring Wells						
Intermediate/deep well couplets (70 and 200 ft bgs)	$15,000	/couplet	3	couplets	$45,000	
Intermediate/deep well couplets (100 and 250 ft bgs)	$21,000	/couplet	3	couplets	$63,000	
				Subtotal:	$2,565,000	
B. Indirect Costs						
Engineering and Design (15%)					$385,000	
Legal and Administrative (10%)					$257,000	
Contingency (25%)					$641,000	
				Total:	$3,848,000	**$3,848,000**

COST ESTIMATE FOR ALTERNATIVE 6B: GROUNDWATER EXTRACTION/AIRSTRIPPING/RE-INJECTION

(REMEDIATION OF AQUIFER TO 125 FT BGS)

New Cassel Industrial Area Off-Site

ITEM	UNIT COST ($)[a]		QUANTITY	COST (2000 $)[b]		Present Worth Cost
O&M COSTS						
Electrical Usage (years 1 - 7)	$0.10	/kW-hr	3,035,340 kW-hr			
			Annual cost for year 1:	$43,000	/yr	$249,000
Chemical Usage (years 1 - 7)	$92,000	/year	7 years			
			Annual cost for year 1:	$92,000	/yr	$532,000
Sludge Disposal (Nonhazardous) (years 1-7)	$2.50	/gallon	4,000 gallon			
			Annual cost for year 1 (560 gallons):	$1,000	/yr	$6,000
Plant Operator (Full-Time)	$75,000	/year	7 years			
			Annual cost for year 1:	$75,000	/yr	$434,000
Vapor Phase GAC						
Carbon, first year	$2.05	/lb	23,000 lb			
			Annual cost for year 1:	$47,000	/yr	$47,000
Carbon (years 2 through 5)	$2.05	/lb	46,000 lb			
			Annual cost for year 2 (assume 11500 lb GAC):	$24,000	/yr	$81,000
Carbon (years 6 though 7)	$2.05	/lb	7,000 lb			
			Annual cost for year 6 (assume 3500 lb GAC):	$7,000	/yr	$10,000
System Monitoring[1]						
System Sampling (first year)	$500	/sample	248 samples			
System Sampling (years 2 through 7)	$500	/sample	216 samples			
			Annual cost for year 1:	$124,000	/yr	$124,000
			Annual cost for year 2:	$14,000	/yr	$68,000
Waste Characteristization of Sludge (first year)	LS			$1,500	/yr	$2,000
Air Monitoring (first year)	$1,000	/sample	6 samples			
Air Monitoring (years 2 through 7)	$1,000	/sample	12 samples			
			Annual cost for year 1:	$6,000	/yr	$6,000
			Annual cost for year 2:	$2,000	/yr	$10,000
Long-Term Groundwater Monitoring Program						
Quarterly sampling of 28 wells (years 1 to 2)	$500	/well	224 wells			
			Annual cost for year 1 (112 wells):	$56,000	/yr	$104,000
Annual sampling of 28 wells (years 3 to 20)	$500	/well	504 wells			
			Annual cost for year 3 (28 wells):	$14,000	/yr	$148,000
Replacement of 3 wells every 5 years	$18,000	/well				
			Annual cost for year 1:	$11,000	/yr	$137,000
Repair/Replacement of Equipment/Well Development (years 1-7)						
(5% of all treatment equipment)	$29,000	/yr	$203,000			
(10% of infiltration gallery)	$14,000	/yr	$98,000			
			Annual cost for year 1:	$43,000	/yr	$249,000
Operation and maintenance of Bowling Green VOC treatment processes [c]						
			Annual cost for year 2000:	$83,000	/yr	$1,034,000
TOTAL PRESENT WORTH FOR ALTERNATIVE:						***$7,089,000***
Based on 7 years of operation, 20 years of groundwater monitoring, and a 5% discount rate.						**Say $7.1 Million**

a - Unit costs are for year 2000.
b - Costs rounded to the nearest $1000.
c - Refer to Alternative 1 (Table 12-2) for itemized Bowling Green O&M costs. Cost includes GAC vessel O&M (including vessel replacement at year 10), air stripper O&M, control/electrical system O&M, electricity, and administrative costs over 20 year period. Cost does not include replacement of air stripping tower.
LS - Lump sum.
1 - Includes one pilot test well.
2 - Includes system performance, groundwater monitoring of extraction wells, and air emissions testing.
- Possible land acquisition costs are not included in the cost estimate.

COST ESTIMATE FOR ALTERNATIVE 7B: GROUNDWATER EXTRACTION/AIRSTRIPPING/RE-INJECTION

(REMEDIATION OF AQUIFER TO 200 FT BGS)

New Cassel Industrial Area Off-Site

ITEM	UNIT COST ($) [a]		QUANTITY	COST (2000 $) [b]	Present Worth Cost
CAPITAL COSTS					
A. Direct Costs					
Treatability Study	LS			$20,000	
Aquifer Pump Test [1] (includes treatment)	$60,000		3	$180,000	
Site Preparation					
Contractor Mobilization/Demobilization	LS			$137,000	
Well Installation					
Drilling and Installation of 150-ft Extraction Well	$42,000	/well	12 wells	$504,000	
Disposal of Soil as Nonhazardous (150-ft well)	$110	/yd³	52.8 yd³	$6,000	
Drilling and Installation of 80-ft Extraction Well	$22,000	/well	1 wells	$22,000	
Disposal of Soil as Nonhazardous (80-ft well)	$110	/yd³	2.3 yd³	$1,000	
Pump, Transducer, Concrete Encasement	$5,000	/well	13 wells	$65,000	
Installation of Connection Piping					
Trenching, Bedding, Pipe, Conduit	$35.00	/lf	10,250 lf	$359,000	
Asphalt Removal, Disposal, Restoration	$42.74	/lf	10,250 lf	$438,000	
Groundwater Treatment					
Treatment System Equipment	LS		-	$453,000	
Air Stripper	$61,000	/unit	1 unit	$61,000	
Electrical Components and Controls	LS		-	$60,000	
Housing for Treatment Operations	LS		-	$260,000	
Infiltration Wells					
Wet Well (8-ft diameter, 15-ft deep)	$20,000	/ well	8 wells	$160,000	
Installation of Monitoring Wells					
Intermediate/deep well couplets (70 and 200 ft bgs)	$15,000	/couplet	3 couplets	$45,000	
Intermediate/deep well couplets (100 and 250 ft bgs)	$21,000	/couplet	3 couplets	$63,000	
			Subtotal:	$2,834,000	
B. Indirect Costs					
Engineering and Design (15%)				$425,000	
Legal and Administrative (10%)				$283,000	
Contingency (25%)				$709,000	
			Total:	$4,251,000	**$4,251,000**

COST ESTIMATE FOR ALTERNATIVE 7B: GROUNDWATER EXTRACTION/AIRSTRIPPING/RE-INJECTION

(REMEDIATION OF AQUIFER TO 200 FT BGS)

New Cassel Industrial Area Off-Site

ITEM	UNIT COST ($)[a]	QUANTITY	COST (2000 $)[b]	Present Worth Cost
O&M COSTS				
Electrical Usage (years 1 - 10)	$0.10 /kW-hr	4,423,800 kW-hr		
		Annual cost for year 1:	$44,000 /yr	$340,000
Chemical Usage (years 1 - 10)	$99,000 /year	10 years		
		Annual cost for year 1:	$99,000 /yr	$764,000
Sludge Disposal (Nonhazardous) (years 1-10)	$2.50 /gallon	6,000 gallon		
		Annual cost for year 1 (600 gallons):	$2,000 /yr	$15,000
Plant Operator (Full-Time)	$75,000 /year	10 years		
		Annual cost for year 1:	$75,000 /yr	$579,000
Vapor Phase GAC				
Carbon, first year	$2.05 /lb	23,000 lb		
		Annual cost for year 1:	$47,000 /yr	$47,000
Carbon (years 2 through 6)	$2.05 /lb	67,500 lb		
		Annual cost for year 2 (assume 13500 lb GAC):	$28,000 /yr	$115,000
Carbon (years 7 though 10)	$2.05 /lb	18,000 lb		
		Annual cost for year 7 (assume 4500 lb GAC):	$9,000 /yr	$24,000
System Monitoring[2]				
System Sampling (first year)	$500 /sample	260 samples		
System Sampling (years 2 through 10)	$500 /sample	342 samples		
		Annual cost for year 1:	$130,000 /yr	$130,000
		Annual cost for year 2:	$19,000 /yr	$129,000
Waste Characteristization of Sludge (first year)	LS		$1,500 /yr	$2,000
Air Monitoring (first year)	$1,000 /sample	6 samples		
Air Monitoring (years 2 through 10)	$1,000 /sample	18 samples		
		Annual cost for year 1:	$6,000 /yr	$6,000
		Annual cost for year 2:	$2,000 /yr	$14,000
Long-Term Groundwater Monitoring Program				
Quarterly sampling of 28 wells (years 1 to 2)	$500 /well	224 wells		
		Annual cost for year 1 (112 wells):	$56,000 /yr	$104,000
Annual sampling of 28 wells (years 3 to 20)	$500 /well	504 wells		
		Annual cost for year 3 (28 wells):	$14,000 /yr	$148,000
Replacement of 3 wells every 5 years	$18,000 /well			
		Annual cost for year 1:	$11,000 /yr	$137,000
Repair/Replacement of Equipment/Well Development (years 1-10)				
(5% of all treatment equipment)	$29,000 /yr			
(10% of infiltration gallery)	$16,000 /yr			
		Annual cost for year 1:	$45,000 /yr	$347,000
Operation and maintenance of Bowling Green VOC treatment processes[c]				
		Annual cost for year 2000:	$83,000 /yr	$1,034,000
TOTAL PRESENT WORTH COST FOR ALTERNATIVE:				***$8,186,000***
Based on 10 years of operation, 20 years of groundwater monitoring, and a 5% discount rate.				**Say $8.2 Million**

a - Unit costs are for year 2000.
b - Costs rounded to the nearest $1000.
c - Refer to Alternative 1 (Table 12-2) for itemized Bowling Green O&M costs. Cost includes GAC vessel O&M (including vessel replacement at year 10), air stripper O&M, control/electrical system O&M, electricity, and administrative costs over 20 year period. Cost does not include replacement of air stripping tower.
LS - Lump sum.
1 - Includes one pilot test well.
2 - Includes system performance, groundwater monitoring of extraction wells, and air emissions testing.
- Possible land acquisition costs are not included in the cost estimate.

protection of human health and the environment, as Class GA standards are achieved for the entire plume area and to depths of 200 ft bgs.

12.3.2 ***Compliance With SCGs.***

Alternative 1 does not comply with any SCGs with the exception of the Federal and state requirement to include a "no action" alternative in the range of detailed evaluation. Alternatives 2 and 3 will not quickly or actively achieve site SCGs. Alternatives 4A, 4B, 5A, and 5B comply with SCGs that relate to groundwater criteria. These four alternatives apply active remediation to “hot spot” areas of groundwater contamination and rely on natural attenuation to assist in achieving remedial objectives. Alternatives 6A, 6B, 7A, and 7B comply with SCGs that relate to groundwater criteria. These alternatives use active treatment across the aerial extent of the off-site groundwater contamination and target NYS Class GA standards to the depths designated in each alternative. Thus, implementation of either Alternative 4A, 4B, 5A, 5B, 6A, 6B, 7A, or 7B would achieve compliance of groundwater SCGs. However, Alternatives 6A, 6B, 7A, and 7B, which address greater extents of the groundwater contamination with active treatment, would likely meet remedial objectives in shorter timeframes than the other alternatives. In addition, it is assumed that any air emissions from an active treatment system will also comply with relevant SCGs.

As noted, Alternatives 6A, 6B, 7A, and 7B achieve the NYS Class GA standards to the designated alternative depths. Alternatives 7A and 7B address the largest quantity of the contaminated off-site groundwater as they remediate the upper and deep portions of the aquifer to a depth of 200 ft bgs.

12.3.3 ***Reduction of Toxicity, Mobility, and Volume Through Treatment.***

Alternatives 1, 2, and 3 will allow natural processes to dissipate the contaminants, but will not create any reduction of toxicity, mobility, or volume of contamination present in the off-site groundwater, as no active remedial measures are included. It should be noted that after yearly technical evaluations of groundwater data and remedial options in Alternative 3, active groundwater treatment (i.e., Alternative 5A) may be established. Alternatives 4A, 4B, 5A, and 5B would result in a permanent decrease in the concentration, mobility, and volume of contaminants present in captured groundwater. However, only “hot spot” areas are addressed with active treatment in these four alternatives. Alternatives 6A, 6B, 7A, and

7B would result in a permanent decrease in the concentration, mobility, and volume of contaminants present in captured groundwater. Class GA standards are achieved at the designated treatment depths via active remediation under each of these four alternatives.

Alternatives 4A, 4B, 6A, and 6B address only the upper portion of the aquifer (i.e., off-site groundwater contamination to a depth of 125 ft bgs). For the in-well vapor stripping and pump and treat scenarios, reductions in toxicity, mobility, and volume of VOCs would be the greatest under Alternatives 7A and 7B (i.e., treatment of the off-site groundwater contaminants to depths of 200 ft bgs).

12.3.4 ***Short-Term Effectiveness.***

Alternatives 1, 2, and 3 result in the least amount of short-term impacts to human health and the environment as the only site activities included (in Alternatives 2 and 3) are monitoring well installation and sampling. Alternatives 4A, 4B, 5A, 5B, 6A, 6B, 7A, and 7B would cause short-term disruptions to the surrounding community due to construction of the remedial components. Alternatives 4A, 4B, 6A, and 6B are likely to have shorter project lives than Alternatives 5A, 5B, 7A, and 7B, respectively, due to the fact that only the upper portion of the aquifer is addressed. Alternatives 4A, 4B, 6A, and 6B are also considered to have less short-term impacts than Alternatives 5A, 5B, 7A, and 7B, respectively, as smaller quantities of system components (e.g., treatment wells, subsurface piping) are generally required.

In addition, higher efficiencies in VOC removal are typically achieved with in-well vapor stripping as compared to groundwater extraction/air stripping. Thus, Alternatives 4A, 5A, 6A, and 7A are anticipated to have shorter project lives than Alternatives 4B, 5B, 6B, and 7B, respectively. The potential hazards to workers implementing the remedy and the surrounding public due to implementation of these alternatives is expected to be minor for the active treatment alternatives. Some noise and traffic would be expected during the brief period of construction of Alternatives 4A, 4B, 5A, 5B, 6A, 6B, 7A, and 7B, with the least amount of disruption anticipated under Alternative 4A.

The scenarios under the in-well vapor stripping alternatives would have less short-term impacts than the respective pump and treat alternatives, as system control and vapor treatment are established at subsurface vaults located next to each well head, and there is no requirement for a large treatment building or extensive lengths of trenching. In the pump and treat alternatives, single central treatment buildings (of about 3,200 sf in Alternatives 4B and 5B, and 4,000 ft^2 in Alternatives 6B and 7B) and trenching for pipelines (ranging from about 3700 to 10,300 l.f., depending on the scenario) are proposed.

12.3.5 ***Long-Term Effectiveness and Permanence.***

Alternatives 4A, 4B, 5A, and 5B permanently remove captured VOC contaminants from the groundwater medium through active remedial processes. However, only "hot spot" areas of groundwater contamination are addressed and natural attenuation is relied upon to help achieve remedial objectives. Alternatives 6A, 6B, 7A, and 7B also permanently remove captured VOC contaminants from the groundwater medium through active remedial processes. The aerial extent of off-site groundwater contamination is addressed with active treatment in these scenarios, and Class GA standards are achieved to the depths designated for each Alternative. Alternatives 1, 2 and 3 do not provide high degrees of long-term effectiveness or permanence as no active remediation measures are proposed. However, it should be noted that a technical analysis of data and remedial options will be made after year 5 in Alternative 3. Alternative 2 (estimated timeframe of 30 years, but possibly longer) may reduce VOC groundwater contamination through in-situ natural attenuation, a passive remedy. Implementation of Alternative 4A, 4B, 5A, 5B, 6A, 6B, 7A, or 7B (all active remedies) is expected to provide a degree of long-term effectiveness and permanence, with implementation of Alternative 7A or 7B (remediation of upper and deep portions of the aquifer to Class GA standards with active treatment) expected to provide the highest degree of long-term effectiveness and permanence.

The estimated timeframes for operating the in-well vapor stripping and pump and treat systems vary between each of the eight alternatives presented, as described in Chapter 11 and Table 12-1. The long-term effectiveness of these alternatives will be optimized by assessing aquifer characteristics, appropriate design of the systems, and the rate of chemical reaction and desorption of the VOC contaminants from aquifer soil particles as required prior to treatment. The estimated remediation timeframes for the in-well vapor stripping and pump and treat alternatives are as follows:

<u>In-Well Vapor Stripping:</u>

- Alternative 4A: 7 years of active remediation plus 13 additional years of natural attenuation (20 year total alternative life).

- Alternative 5A: 9 years of active remediation plus 11 additional years of natural attenuation (20 year total alternative life).
- Alternative 6A: 5 years of active remediation (20 year total alternative life, including long-term groundwater monitoring program).
- Alternative 7A: 7 years of active remediation (20 year total alternative life, including long-term groundwater monitoring program).

Groundwater Extraction/Air Stripping:

- Alternative 4B: 9 years of active remediation plus 11 additional years of natural attenuation (20 year total alternative life).
- Alternative 5B: 12 years of active remediation plus 8 additional years of natural attenuation (20 year total alternative life).
- Alternative 6B: 7 years of active remediation (20 year total alternative life, including long-term groundwater monitoring program).
- Alternative 7B: 10 years of active remediation (20 year total alternative life, including long-term groundwater monitoring program).

The actual timeframes for the active remedies may be longer if the existing subsurface conditions prove to be less than ideal. Aquifer pump tests and/or pilot tests may lead to better estimates of the required remedial timeframes.

12.3.6 ***Implementability.***

All eleven alternatives are readily implementable. Alternative 1 is the easiest of the alternatives to implement (No Further Action). Alternative 2 involves monitoring well installation, a site characterization program, establishment of institutional measures, and long-term MNA monitoring. Alternative 3 is also straightforward, as only the construction of monitoring wells, establishment of institutional measures, and a long-term monitoring program are required. Alternatives 4A, 5A, 6A, and 7A involve the installation of in-well vapor stripping wells and a vapor treatment system. It should be noted that in-well vapor stripping is a relatively new, innovative technology for groundwater remediation and has not been as widely demonstrated as the pump and treat technology. The in-well vapor stripping technology is licensed to a small number of vendors and requires specialized experience to implement. Treatment wells and vaults can be located in streets or rights-of-way, and little or no land acquisition is required. Alternatives 4B, 5B, 6B, and 7B include the installation of a groundwater extraction and treatment system, which is a commonly applied technology at inactive hazardous waste sites. Under each of these four pump and treat scenarios, land would need to be acquired for the installation of a central treatment building (3,200 - 4,000 ft^2) and wet wells for effluent re-injection.

12.3.7 ***Cost.***

The costs of each remedial alternative are summarized in Table 12-1. Alternative 1, the no further action alternative, has the lowest estimated present worth ($1.5 million) of the remedial alternatives. Alternative 3, Monitoring, Assessment, and Contingent Remediation, has an estimated cost of $2.2 million. Monitored Natural Attenuation, Alternative 2, has an estimated cost of $2.4 million.

Alternative 4A (remediation of upper portion of aquifer [to 125 ft bgs] with in-well vapor stripping) has an estimated present worth cost of $2.8 million. Alternative 5A (remediation of upper and deep portions of aquifer [to 200 ft bgs] with in-well vapor stripping) was found to have the fifth lowest estimated present worth cost $3.6 million). Alternative 6A (full plume remediation of upper portion of aquifer [to 125 ft bgs] with in-well vapor stripping, $3.7 million) and Alternative 7A (full plume remediation of upper and deep portions of aquifer [to 200 ft bgs] with in-well vapor stripping, $4.9 million) had the sixth and seventh lowest estimated present worth costs, respectively. Alternative 4B (remediation of upper portion of the aquifer [to 125 ft bgs] with groundwater extraction/air stripping) was found to be the least expensive pump and treat alternative (eight least expensive overall), at an estimated present worth cost of about $5.0 million. Pump and treat alternatives 5B (remediation of upper and deep portions of the aquifer [to 200 ft bgs]) and 6B (full plume remediation of upper portion of aquifer [to 125 ft bgs]) were next in estimated costs at $5.3 million and $7.1 million, respectively. Alternative 7B (full plume remediation of upper and deep portion of aquifer [to 200 ft bgs] with groundwater extraction/air stripping) was found to be the most expensive FS alternative, with an estimated present worth cost of $8.2 million.

For each active treatment technology, the systems that address the upper and deep portions of the aquifer were found to be more costly than the corresponding systems that address only the upper portion of the aquifer. An analysis of the two active treatment technologies conducted for this FS found that for in-well vapor stripping, the local treatment alternatives were typically less expensive and easier to implement than comparative central treatment alternatives. Conversely, for the pump and treat alternatives, the central treatment systems were less costly and easier to implement than comparative local treatment scenarios. Appendix L summarizes these findings.

Individual alternative cost tables for the active remedies are included in Tables 12-5 through 12-12. Land acquisition costs that will likely be associated with the groundwater extraction/air stripping alternatives are not included in the cost estimates within this FS. All of the alternatives include O&M costs associated with the treatment of VOCs at the Bowling Green Water District for the duration of the alternative life (i.e., 20 - 30 years). Table 12-13 summarizes the operation and maintenance costs associated with the Bowling Green VOC treatment processes for each alternative. This present worth costs ranges from about $1.0 million (for 20-year alternatives) to $1.5 million for Alternatives 1, 2, and 3 (30 year project lives).

TABLE 12-13

SUMMARY OF O & M COSTS for BOWLING GREEN WATER DISTRICT VOC REMOVAL PROCESSES

NCIA Off-Site Groundwater

Alternative	Project Life (years)	Associated O&M Cost for VOC Treatment Processes[1]
1. No Further Action	30	$1.48 million
2. Monitored Natural Attenuation	30	$1.48 million
3. Monitoring, Assessment, and Contingent Remediation	30	$1.48 million
4A. In-well Vapor Stripping (to 125 ft bgs)	20	$1.03 million
4B. Pump & Treat (to 125 ft bgs)	20	$1.03 million
5A. In-well Vapor Stripping (to 200 ft bgs)	20	$1.03 million
5B. Pump & Treat (to 200 ft bgs)	20	$1.03 million
6A. In-well Vapor Stripping (to 125 ft bgs) (full plume remediation)	20	$1.03 million
6B. Pump & Treat (to 125 ft bgs) (full plume remediation)	20	$1.03 million
7A. In-well Vapor Stripping (to 200 ft bgs) (full plume remediation)	20	$1.03 million
7B. Pump & Treat (to 200 ft bgs) (full plume remediation)	20	$1.03 million

1 Present worth cost based on alternative project life and 5% discount rate.

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