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FMC Corporation
Middleport, New York

RCRA Facility Investigation (RFI) Report

Volume I

Background and Related Information

Revised September 2009 FINAL

ARCADIS AMEC Geomatrix

RCRA Facility Investigation Report

Volume I
Background and Related Information

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Acronyms, Abbreviations, and Units of Measurement

Agencies	NYSDEC and USEPA
AICM	Additional Interim Corrective Measure
AMSL	above mean sea level
AOC	Administrative Order on Consent
AOCn	Area of Concern
bgs	below ground surface
BHC	benzene hexachloride
CAMU	Corrective Action Management Unit
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIG	Community Input Group
CMS	Corrective Measures Study
COCs	constituents of concern
CSI	Central Surface Impoundment
CWM	Chemical Waste Management
DDD	dichlorodiphenyldichloroethene
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DNOC	dinitrocresol
DOD	Department of Defense
EBDC	ethylenebisdithiocarbamate
EP	Extraction Procedure

ERM	Environmental Resources Management, Inc.
ESI	Eastern Surface Impoundment
ETU	ethylene thiourea
F	Fahrenheit
FEMA	Federal Emergency Management Administration
FMC	FMC Corporation
GCL	geosynthetic clay layer
GIPL	Groundwater Indicator Parameter List
GMP	Groundwater Monitoring Program
GPM	gallons per minute
HDPE	high-density polyethylene
ICM	Interim Corrective Measure
IRM	Interim Remedial Measure
Maxim	Maxim Technologies, Inc.
NPDES	National Pollutant Discharge Elimination System
NWCA	Northwest Conrail Area
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOL	New York State Department of Labor
O&M	operations and maintenance
OSI	Off-Site Investigation
P&A	Plugging and Abandonment
ppm	parts per million

PTI	PTI Environmental Services
PVC	polyvinyl chloride
R&D	Research and Development
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
ROW	right-of-way
Roy-Hart	Royalton-Hartland
SAP	Science Advisory Panel
SGQAMP	Site Groundwater Quality Assessment Monitoring Plan
SI	Site Investigation
SPDES	State Pollutant Discharge Elimination System
SSPL	Site-Specific Parameter List
SWIM	Surface Water Impoundment Monitoring
SWMU	Solid Waste Management Unit
TSDF	Treatment, Storage, and Disposal Facility
USEPA	United States Environmental Protection Agency
VOCs	volatile organic compounds
WSI	Western Surface Impoundment
WTP	Water Treatment Plant

1. Introduction

FMC Corporation (FMC) owns and operates a pesticide formulations facility ("Facility" or "Site") in Middleport, New York. The Site has been used for manufacturing and/or formulation of pesticide products since the 1920s. FMC is implementing a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for this Facility to delineate and evaluate the presence of Site-related constituents in soil, surface water, sediment, soil gas, indoor air and/or groundwater at the Facility and in off-Site areas as a result of releases of hazardous waste or hazardous constituents from the Facility into the environment. The RFI is one of several related investigative, monitoring and/or remedial programs being implemented to satisfy the terms and conditions of the Administrative Order on Consent (AOC) (Docket No. II RCRA-90-3008(h)-0209) entered into by FMC, the New York State Department of Environmental Conservation (NYSDEC), and the United States Environmental Protection Agency (USEPA), and effective July 2, 1991 (USEPA, NYSDEC, and FMC 1991).The purpose of the RFI is to characterize the nature and extent of releases of hazardous waste or hazardous constituents from regulated units, Solid Waste Management Units (SWMUs) or groups of SWMUs, and other potential sources at the Facility and to gather necessary data (existing and new) to support a Corrective Measures Study (CMS), if one is determined to be necessary. This RFI Report defines the nature and extent of Site-related constituents within the current Facility boundary (including the Plant Site and the North Railroad Property) and off-Site areas that may have been impacted by historical releases of hazardous wastes or hazardous constituents at the Facility.

The off-Site study areas consist of:

Non-FMC-owned properties bordering the Facility including FMC's former Research and Development Property (Former R&D Property), Royalton-Hartland (Roy-Hart) Central School District Property, and residential, agricultural, commercial and industrial properties.

Off-Site areas potentially impacted by deposition from historic air emissions.

Culvert 105 storm sewer system and its flood zone.

Tributary One and its floodplain.

Jeddo Creek and its floodplain downstream of its confluence with Tributary One, and Johnson Creek downstream of its confluence with Jeddo Creek.

Other areas studied for background purposes only.

The RFI focused on the characterization of soil, surface water, sediment, subsurface gas, indoor air, and/or groundwater quality at the Facility and/or within certain off-Site study areas. The scope of the off-Site studies was based on potential historic transport pathways from the Site. The potential transport pathways included historic air deposition, surface water runoff and discharges, vapor intrusion, and groundwater migration.

1.1 Background

The RFI sampling and analysis activities were performed in numerous phases from 1993 to date. FMC has developed and implemented a number of RFI project-specific work plans and reports at the direction of the NYSDEC and USEPA (collectively referred to as the "Agencies") under the terms and conditions of the AOC. In addition, data generated from relevant investigative and monitoring programs and interim remedial actions have also been used during performance of the RFI. A Draft RFI Report (CRA 1999a) presenting the RFI sample results collected from 1993 through 1997 and sampling data collected as part of other environmental investigations conducted at and around the Facility from the 1970s through 1997 was submitted to the Agencies in January 1999. Subsequent to the January 1999 submittal, FMC conducted additional investigative and remedial activities from 1998 through 2007 that generated data in support of the RFI. Section 1.3 further describes these efforts.

In late 2005, FMC and the Agencies agreed that a Revised RFI Report would be prepared to present and summarize the RFI sampling data and results. This Revised RFI Report has been divided into several volumes. Each volume will address a particular study area and/or media (e.g., soil, groundwater). The volumes of the complete Revised RFI Report include:

- Volume I – Background and Related Information.
- Volume II – Suspected Air Deposition Study Area South of the Erie Canal and West of the Niagara/Orleans County Line.
- Volume III – Former R&D Property.

- Volume IV – Culvert 105 and Flood Zone.
- Volume V – Tributary One and Floodplain South of Pearson/Stone Roads.
- Volume VI – Tributary One and Floodplain North of Pearson/Stone Roads.
- Volume VII – Jeddo Creek, Johnson Creek, and Floodplains.
- Volume VIII – Groundwater Investigations and Remediation Results.
- Volume IX – On-Site Soil, Surface Water, and Sediments.
- Volume X – Suspected Air Deposition Study Area North of the Erie Canal and East of the Niagara/Orleans County Line.
- Volume ES – Comprehensive Executive Summary for all Volumes.

1.2 Volume I – Report Organization

This document represents Volume I of the Revised RFI Report – Background and Related Information. It provides background information that is pertinent to the evaluation of the data for each of the study areas and /or media. Volume I is organized as follows:

Section 1 – Introduction: Identifies the objectives of the RFI and describes the RFI program.

Section 2 – Background: Describes the Facility location and layout; the history of production activities at the Facility; the history of spills, air emissions, and waste production and disposal at the Facility; and off-Site study areas.

Section 3 – Previous and Ongoing Investigations and Monitoring Programs: Identifies and describes previous and ongoing Site-related investigative and monitoring programs pertinent to the RFI.

Section 4 – Previous and Ongoing Remedial Activities: Identifies and describes the previous and ongoing remedial activities at the Facility and in off-Site areas.

Section 5 – Regional Setting: Characterizes the regional setting including demographics, climate, geology, hydrogeology, groundwater usage, regional surface water bodies, and describes the settings of the off-Site study areas.

Section 6 – Middleport Area Soil Background Studies: Identifies previous studies performed to determine soil background conditions.

Section 7 – References: Presents the reference sources used while developing Volume I of the Revised RFI Report.

1.3 RFI Objectives and Description

The general objectives of the RFI are to:

- Characterize the nature and extent of releases of hazardous waste and hazardous constituents from source areas at the Facility.
- Define existing and potential migration pathways of hazardous waste and hazardous constituents.
- Define the physical features that affect or could affect the migration, containment, or remediation of hazardous waste and hazardous constituents.
- Provide data needed to evaluate potential human health risk and ecological risk.
- Gather all information necessary to support the development and evaluation of a corrective measure or measures during the CMS, if determined to be necessary.

To achieve the above objectives, FMC used the data generated from relevant investigative programs and interim remedial actions (from 1970s to date) and obtained data from numerous RFI sampling and analysis phases conducted from 1993 through 2007. The investigations, remedial programs, and RFI sampling and analysis events that generated data relative to the RFI include the following:

- Comprehensive Site Investigation (1985 to 1987).

- Groundwater monitoring programs, including the Groundwater Monitoring Program (GMP) required under the terms and conditions of the AOC (1985 to present).

- Various soil sampling programs for the Roy-Hart school property (1985 to 1990).

- Northern Ditches Restoration IRM Program (1987-1988).

- Off-Site Investigation (OSI) (1990 to 1993).

- RFI field sampling and analysis specified in the approved RCRA Facility Investigation Work Plan (RFI Work Plan) (CRA 1993b), and in subsequent supplemental RFI sampling and analysis work plans approved by the Agencies (results of the 1993-1997 RFI field investigations are included in the Draft RFI Report [CRA 1999a]) (1993 to 1997).

- Continued operation of the groundwater Interim Corrective Measures (ICMs) including the Western Surface Impoundment (WSI) underdrain and collection sump system from 1977 to present, the sanitary sewer underdrain and collection sump system from 1981 to present, and the bedrock groundwater extraction wells and other collection sumps at the Facility from 1987 to present.

- Expansions of the bedrock groundwater extraction system ICMs at the Facility and associated hydraulic effectiveness evaluations (1994, 1995, 1998-1999, and 2005).

- Groundwater ICM Hydraulic Performance Monitoring (completed in 2000-2002).

- Royalton-Hartland School Bleacher Area IRM Excavation Project (1996).

- Royalton-Hartland School Football Field Area ICM Excavation Project (1999 to 2000).

- Private Water Well Study, including an inventory and sampling of private wells (2000 to 2002).

- Development of Arsenic Background Concentration in Middleport soils, also referred to herein as the 2001-2003 Gasport Area Background Study (2001 to 2003).

- 2002 Sampling Program (2002 to 2003).

- Supplemental Hydraulic Performance Assessment of Groundwater ICMs (2002 to 2004).

- Supplemental Downgradient Groundwater Investigation (2002 to 2004).

- Western Properties Soil and Former Sewer Removal ICM (2003).

- Evaluation of Arsenic Bioavailability from Middleport soil (2004 to 2006).

- Middleport Environmental Exposure Investigation (Biomonitoring Study) (2003 to 2004).

- North Railroad Property RFI Sampling and Analysis (2003 to 2005).

- Tributary One South of Pearson/Stone Roads and Culvert 105 RFI Sampling and Analysis (2003 to 2006).

- Areas Potentially Affected by Historic Air Deposition RFI Soil Sampling and Analysis (2004 to 2007).

- Off-Site vapor intrusion studies (completed 2005-2007), which included the August 2005 sampling and analysis of soil gas from the Roy-Hart school yard; August 2005 installation of two new monitoring wells; fall 2005 groundwater sampling and analysis for volatile organic compounds (VOCs) of the new and existing monitoring wells; March 2006 sampling and analysis of ambient air, indoor air, crawl space air and sub-slab vapor at the Roy-Hart school buildings; April 2006 sampling and analysis of the Roy-Hart Acid Drain; implementation of the VOC Groundwater Investigation beginning in April 2006 (consisting of the installation of six new monitoring wells the sampling and analysis of new and existing groundwater wells for VOCs); continued groundwater sampling and analysis for VOCs as part of the GMP; and February 2007 follow-up sampling and analysis of ambient air, indoor

air, crawl space air and sub-slab vapor at the Roy-Hart Middleport school buildings.

- Phase 1 ICM North Railroad Property-Soil Removal and Cover Installation (2005).
- Phase 2 ICM North Railroad Property-Northwest Conrail Area (2007 to present).
- Early Actions for the eastern portion of the North Commercial/Industrial Area, known as the Wooded Parcel, the open ditch segments of Culvert 105 south of Sleeper Street, and residential properties along the south side of Park Avenue and between Maple Avenue and Alfred Street (P-Block Properties) (2007).
- On-Site vapor intrusion study (2006 to present).
- RFI Soil and Sediment Sampling Along Tributary One North of Pearson Road, Jeddo Creek and Johnson Creek (2006 to present).

FMC has developed and implemented project-specific work plans and prepared a number of reports in support of the RFI and other activities described above on its own initiative or at the direction of the Agencies under the terms and conditions of the AOC. Key documents that contain RFI-related data/information include:

- RFI Work Plan (CRA 1993b), including a Project Management Plan (PMP) and a Data Management Plan (DMP), and supplemented by a September 10, 1993 letter and submittal.
- Data Collection Quality Assurance Plan (DCQAP) (CRA 1993f).
- Addendum No. 1, Health and Safety Plan (HASP) (CRA 1993e).
- Community Relations Plan (CRP) (CRA 1993d).
- Draft RFI Report (CRA 1999a).
- Surface Soil Data Comparison Work Plan, Roy-Hart School Property (CRA 1999d).

- Private Water Well Study Work Plan (CRA 2000a).
- Interim Corrective Measures Work Plan, Roy-Hart School Football Field Area Excavation Project (CRA 1999b).
- Interim Corrective Measures Construction Report, Roy-Hart School Football Field Area Excavation Project (CRA 2000b).
- Program To Determine Extent of FMC-Related Arsenic Contamination in Middleport Soil: Part A-Work Plan for Development of Arsenic Background in Middleport Soil (Agencies 2001).
- Groundwater Interim Corrective Measures Hydraulic Performance Monitoring Results (CRA 2002b).
- Private Water Well Study Summary Report (CRA 2002c).
- Supplemental Downgradient Groundwater Investigation Work Plan (Geomatrix 2002a).
- 2002 Sampling Program Work Plan (CRA 2002d)
- Draft 2002 Sampling Program Report (CRA 2003b).
- Western Residential Properties Soil and Former Sewer Removal Interim Corrective Measures Work Plan (CRA 2003c).
- Work Plan for the Middleport Environmental Exposure Investigation (Exponent 2003).
- Tributary One South of Pearson/Stone Roads & Culvert 105 North of the Canal RCRA Facility Investigation/Corrective Measures Study Work Plan (CRA 2003d).
- North Railroad Property Work Plan RCRA Facility Investigation/Corrective Measures Study (Geomatrix and CRA 2003).
- Protocol for Evaluation of Dermal Arsenic Absorption from Middleport Soil (Webster and Schoof 2004).

- Supplemental Hydraulic Performance Assessment of Groundwater Interim Corrective Measures (Geomatrix 2004a).
- Soil Sampling Work Plan - Areas Potentially Affected by Historic Air Deposition (Blasland, Bouck & Lee, Inc. [BBL] 2004a).
- Culvert 105 Video Inspection Results (BBL 2004b).
- Middleport Environmental Exposure Investigation (Exponent 2004a).
- Supplemental Groundwater Investigation Results (Geomatrix 2004b).
- Addendum No. 2 to the RFI/CMS Work Plan - Additional RFI Sampling Along Tributary One South of Pearson/Stone Roads & Culvert 105 (BBL and Geomatrix 2004).
- Technical Report on Data Sufficiency for the North Railroad Property (BBL 2005b).
- Off-Site Soil Gas Investigation Work Plan (BBL 2005e), Addendum No. 1 to Off-Site Soil Gas Investigation Work Plan (BBL 2006a), and Addendum No. 2 to the Off-Site Soil-Gas Investigation Work Plan (Geomatrix 2007a).
- Off-Site Vapor Intrusion Investigation Report (BBL 2006b) and letter report that presents the results of the February 2007 follow-up sampling (ARCADIS BBL 2007a).
- Phase I ICM Work Plan for the North Railroad Property (BBL 2005d).
- Addendum No. 3 to the October 2003 RFI/CMS Work Plan for Tributary One South of Pearson/Stone Roads and Culvert 105 South of Pearson/Stone Roads (BBL 2005f).
- Addendum No. 1 to the July 2004 Soil Sampling Work Plan – Areas Potentially Affected by Historic Air Deposition (BBL 2005g).
- 2005 Groundwater ICM Construction and Performance Report (BBL 2005h).

- Final Construction Report for the North Railroad Property Phase I Interim Corrective Measure (BBL 2006c).
- Sampling Work Plan - Tributary One North of Pearson Road, Jeddo Creek and Johnson Creek (BBL 2006d).
- VOC Groundwater Investigation Work Plan (Geomatrix 2006).
- Operation, Maintenance, and Monitoring Plan for the North Railroad Property Phase 1 Interim Corrective Measures (Phase 1 ICM OM&M Plan) (BBL 2006e).
- Construction Report for the West Properties Soil and Former Sewer Removal ICMs (Geomatrix 2007b).
- Supplemental Report, Results of Bedrock Groundwater Isotope Investigation (Geomatrix 2007c).
- On-Site Vapor Intrusion Investigation Work Plan (Geomatrix 2007d).
- Background Arsenic Soil Concentrations in Middleport, New York (Gradient Corporation 2007).
- Phase 2 Interim Corrective Measures Work Plan for the North Railroad Property (ARCADIS BBL 2007b).
- 2007 Early Actions Work Plan (ARCADIS BBL 2007c) and Addendum No. 1 to the 2007 Early Actions Work Plan (ARCADIS BBL 2007d).
- Technical Memorandum that summarizes the Middleport soil arsenic biological absorption testing results (titled Testing Arsenic Absorption from Middleport, NY Soils (see Appendix 3D).
- The field investigation work tasks outlined in the approved RFI Work Plan (CRA 1993b) consisted of the following:
- Waste characterization of select SWMUs or SWMU groups, which involved the collection of subsurface soil samples from 27 boreholes installed within

or adjacent to the limits of the 11 SWMU groups and analyses of the soil samples for a comprehensive list of Site-specific parameters.

- Groundwater investigation that included the installation of one new overburden, one new shallow, and one new deep bedrock off-Site groundwater monitoring well, collection of groundwater samples from the new and selected existing monitoring wells, and analyses of the groundwater samples for a comprehensive list of Site-specific parameters.

- Development of media-specific indicator parameter list or lists used in any subsequent investigation activities.

- Preparation of a Field Investigation Summary Report (CRA 1994b).

- Performance of a supplemental field investigation(s), if required and as approved by the Agencies.

- The above RFI soil investigation field work activities were performed in late 1993. The results of the RFI soil investigation activities were provided to the Agencies in the RFI Field Investigation Summary Report (RFI Summary Report) (CRA 1994b), which recommended the collection of additional soil samples east of the Facility. The above RFI groundwater field activities were performed in 1994 and 1995 (delays in obtaining access permission for the well installations were encountered) in conjunction with FMC's ongoing GMP and were summarized in the document titled RCRA Facility Investigation Groundwater Investigation Sampling Report (CRA 1996b).

By letter dated April 12, 1995 (Agencies 1995a), the Agencies provided comments on the RFI Field Investigation Summary Report, and directed the installation and sampling of additional off-Site groundwater monitoring wells and additional soil sampling on-Site and in off-Site areas, some of which had been part of an extensive Off-Site Investigation (OSI) performed by FMC under a separate Order on Consent (Index No. B9-0221-88-04) with the NYSDEC (NYSDEC and FMC 1990).

Following the Agencies' comments on the RFI Field Investigation Summary Report, FMC performed the following supplemental RFI field investigation activities approved by the Agencies from 1995 to 1997:

- Installation and sampling of eight new RFI/GMP groundwater monitoring wells in off-Site areas.

- Collection of additional soil samples in off-Site locations around the Facility in July 1996 (on-Site locations along FMC's southern property boundary were also sampled in July 1996) and November 1996 in accordance with the Agencies-approved work plans.

In addition, the Agencies performed additional off Site soil sampling and analyses, with split samples analyzed by FMC, for the purposes of the RFI. By letter dated July 16, 1997, the Agencies notified FMC that the soil database was sufficient for FMC to prepare and submit the Draft RFI Report (Agencies 1997b). A Draft RFI Report was submitted to the Agencies by cover letter dated November 4, 1997. The Agencies provided comments on the November 1997 draft report by cover letter dated March 26, 1998 (Agencies 1998a). The Agencies' March 1998 comments and other comments made during subsequent meetings and correspondences were incorporated into a revised report. The revised Draft RFI Report was submitted to the Agencies by cover letter dated January 29, 1999 (CRA 1999a).

The 1999 Draft RFI Report (CRA 1999a) proposed additional groundwater characterization activities which included the following:

- Installation of three new monitoring wells and inclusion of those new wells and two existing wells into the semi-annual GMP sampling program.

- Update of the private water well survey and collection of water samples from selected private wells.

- Further evaluation of ammonia presence in the deep bedrock.

- Development and implementation of a hydraulic performance monitoring program for the groundwater extraction systems.

These groundwater characterization activities have been performed as part of several programs listed above and are further discussed in Section 3.3 of this Revised RFI Report.

By letter dated June 14, 2005, the Agencies directed FMC to conduct vapor intrusion studies at its "Plant Site" and at off-Site areas north of the Facility (i.e., at Roy-Hart

School property) as part of a state-wide initiative to evaluate potential vapor intrusion at remediation sites in New York State where VOCs have been found in soil and/or groundwater. FMC agreed to perform the work in accordance with the terms and conditions of the AOC and began the off-Site studies in August 2005. FMC submitted a work plan for the on-site evaluation in October 2005 (BBL 2005i). FMC submitted a revised work plan in June 2007 in response to January 2007 comments from the Agencies and subsequent discussions. Following resolution of further comments from the Agencies in November 2007, sampling was conducted in late March 2008. Section 3.3 of this report further discusses the vapor intrusion studies.

The 1999 Draft RFI Report also stated that additional interim remedial actions would be performed or proposed, including the Groundwater ICM Hydraulic Performance Monitoring (completed in 2000-2002), the Royalton-Hartland School Football Field Area ICM Excavation Project (completed in 1999-2000), the purchase of the Northern Ditches and the Northwest Conrail Area from Consolidated Railroad Corporation ("Conrail") (both of which were purchased by FMC in May 2002), and the proposal and performance of ICMs on the FMC-owned railroad property. These ICMs have been performed as part of several programs listed above and are discussed in Section 4 of this report.

In mid to late 2001, FMC requested that the Agencies enter into discussions with FMC concerning the completion of the RFI and CMS and the goal of achieving the USEPA RCRA Environmental Indicators for the Site. FMC and the Agencies met on December 19, 2001. Two major topics were discussed during the December 2001 meeting: 1) FMC's proposal for ICMs at certain off-Site study areas, including the removal of soil and the FMC's former outfall sewer on the residential properties that abut the Facility's western fenceline (completed in 2003 as the West Properties Soil and Former Sewer Removal ICM project) and the installation of a soil cover on the Northwest Conrail Area; and 2) the remaining tasks necessary to accelerate and complete the RFI, CMS, and to achieve the USEPA RCRA Environmental Indicators for the Site by 2005. Based on the December 19, 2001 discussions, the Agencies provided FMC, by letter dated January 11, 2002, a discussion of potential issues concerning FMC's ICM proposal and a summary of "data gaps" in the RFI. Additionally, as a result of the December 19, 2001 discussions, FMC and the Agencies agreed to hold weekly technical group conference calls beginning in January 2002 to discuss specific technical issues concerning the proposed ICMs and the completion of the RFI and CMS.

As a result of the weekly technical group conference calls held in early 2002, FMC and the Agencies agreed to perform additional soil sampling and analysis studies to address the RFI data gaps (the 2002 Sampling Program), and to re-evaluate local soil arsenic background values (the 2001-2003 Gasport Area Background Study). Both of these studies were completed in 2003, as further discussed in Section 3.4 of this report. The 2002 Sampling Program consisted of soil sampling and analyses in the following then off-Site study areas: North Commercial/Industrial Area; the 14 Western Residential Properties ICM Area; FMC's Former R&D Property; the North Railroad Property (i.e., the Northern Ditches and Northwest Conrail Area); the floodplains of Culvert 105 and Tributary One South of Pearson/Stone Roads. The Agencies reviewed the results of the 2002 Sampling Program and determined that additional sampling and analysis was warranted in certain off-Site Study areas. From 2003 through 2006, FMC performed several additional phases of RFI sampling and analysis from off-Site or former off-Site study areas including the North Railroad Property, Culvert 105 and its flood zone, Tributary One and its floodplain South of Pearson/Stone Roads, off-Site areas potentially impacted by deposition from historic air emissions, Tributary One and its floodplain north of Pearson Road, Jeddo Creek and its floodplain downstream of its confluence with Tributary One, and Johnson Creek downstream its confluence with Jeddo Creek. Section 3.4 further discusses the RFI-related soil sampling and analysis conducted from 2003 through 2006.

FMC and the Agencies met on August 30, 2005 to discuss the soil arsenic data sufficiency, the scope of work for additional soil sampling and analysis proposed by the Agencies for fall 2005, and the preparation of the revised draft RFI Report. FMC provided the Agencies a draft outline for the revised draft RFI report during the meeting. By letter dated September 21, 2005, the Agencies determined that additional arsenic soil sampling was needed in certain areas along Tributary One and Culvert 105 south of Pearson/Stone Roads and in certain areas around the Facility that may have been potentially affected by historic air deposition from the Facility.

Subsequent to the August 30, 2005 meeting, FMC agreed to perform additional sampling and analysis as proposed in Addendum No. 3 to the October 2003 RFI/CMS Work Plan for Tributary One South of Pearson/Stone Roads and Culvert 105 South of Pearson/Stone Roads (BBL 2005f) and Addendum No. 1 to the July 2004 Soil Sampling Work Plan – Areas Potentially Affected by Historic Air Deposition (BBL 2004a). Sample collection began on November 28, 2005 and was completed in mid December 2005. Sample analysis and data validation was completed in early 2006. The Agencies approved the November/December 2005 sample data quality by letter dated May 31, 2006.

In spring 2006, FMC began implementation of the RFI-related soil and sediment sampling and analysis from areas within and along the floodplain of Tributary One North of Pearson Road, Jeddo Creek and Johnson Creek. Sample analysis and data validation were completed late 2006 and the sampling data were provided to the subject property owners in early 2007. The Agencies and FMC are reviewing the data sufficiency for the North of Pearson Road study areas.

The Agencies completed a data sufficiency review for the Tributary One South of Pearson/Stone Roads, Culvert 105, and the Historic Air Deposition Off-Site study areas and issued their determinations to FMC by letter dated September 24, 2007. FMC and the Agencies discussed the Agencies' determinations at meetings held on December 11, 2007 and on February 14, 2008. The Agencies have determined that separate RFIs and CMSs should now be completed (similar to an "operable unit" concept) for each of the following three study areas:

Culvert 105 and the flood zone.

Tributary One & floodplain south of Pearson Road.

- Suspected air deposition study area south of the Erie Barge Canal and west of the Niagara/Orleans County Line (which includes the North Commercial/Industrial Area, the 14-Western Residential Properties and the Royalton-Hartland School Property).

2. Background

2.1 Location of FMC Facility and Study Areas

The RFI characterizes the nature and extent of releases of hazardous waste or hazardous constituents from regulated units, SWMUs or groups of SWMUs, and other source areas at the FMC Middleport Facility, and includes both the plant Site and off-Site areas. In addition, other properties in the vicinity of Middleport (e.g., Gasport) were sampled as part of the RFI to characterize arsenic soil conditions in areas that have not been impacted by historic operations at the FMC Plant Site. The RFI study areas, including the background study areas, consist of the following:

- FMC's Facility, which includes the FMC Plant Property and the North Railroad Property (purchased by FMC in 2002).
- FMC's former Research and Development Property (Former R&D Property).
- Historic Air Deposition Off-Site Study Area consisting of non-FMC owned residential, agricultural, public, commercial and industrial properties near the FMC Facility that may have been potentially impacted by deposition from historic air emissions at the Facility (e.g., the Roy-Hart Central School Property, agricultural fields to the east and northeast of the Facility, the North Commercial/Industrial Area, 14 Western Residential properties, and other residential and some commercial properties around the Facility).
- Culvert 105 storm sewer consisting of buried pipe and open swale sections north and south of the Erie Barge Canal and areas traversed by Culvert 105.
- Tributary One South of Pearson/Stone Roads and its floodplain (approximately from the Middleport Reservoir to Pearson/Stone Roads).
- Tributary One North of Pearson Road and East of Stone Road and its floodplain (approximately from Stone Road to its confluence with Jeddo Creek) and contributing swales.
- Jeddo Creek and its floodplain (approximately from its confluence with Tributary One to its confluence with Johnson Creek) and contributing swales.

- Johnson Creek and its floodplain (approximately from its confluence with Jeddo Creek to the Johnson Creek Pond in Lyndonville) and contributing swales.

- Gasport Properties (approximately 4.5 miles west of the FMC Facility) consisting of orchards, agricultural fields, wooded areas, commercial/industrial properties, and residential areas – only for characterization of area background arsenic soil conditions.

- A portion of the Erie Canal within the Village of Middleport – only for characterization of upstream/background conditions.

- Eighteen Mile Creek in the vicinity of Gasport – only for characterization of upstream/background conditions.

The Facility is situated in the southeast corner of the Village of Middleport and in the Town of Royalton, New York in Niagara County. The off-Site Study Areas include Niagara County properties situated within the Village of Gasport, Village of Middleport, the Town of Royalton, the Town of Hartland, and Orleans County properties situated within the Town of Ridgeway and the Town of Yates. Figure I2.1 shows the location the Facility and adjacent municipalities. Figure I2.2a and Figure I2.2b show the FMC Facility and the study areas south of Pearson/Stone Roads. Figure I2.3 presents a layout of the Facility. Figure I2.4 presents an aerial photo (taken in 2000) of the Facility.

The Facility is bounded by residential properties to the west (along South Vernon Street), agricultural lands to the east, an automobile junkyard to the southeast, a commercial business to the southwest (situated on FMC's Former R&D Property), and a state highway (Route 31) to the south. A drive-in theater, a church, a park, commercial businesses, and residential properties are located south of the Facility and Route 31. Properties that abut the northern property boundary of the FMC-owned North Railroad Property consist of a farm field, the Roy-Hart High School and Middle School, the southern right-of-way for Alfred Street (owned by the Village of Middleport), a vacant commercial property (referred to as the "Wooded Parcel") and other commercial/industrial properties.

The current zoning of properties within study areas south of Pearson Road is identified on Figure I2.5. Figure I2.6 identifies historic land usages for the study areas south of Pearson Road. The historic land use information was compiled based on

historic fire insurance maps (Sanborn Maps), aerial photographs (dated 1931, 1938, 1951, 1958, 1966, 1968, 1971, 1973, 1977 and 1978) and other information obtained from property owners (see Appendix 2E). Figure I2.7 identifies the current zoning of the study areas north of Pearson/Stone Roads along Tributary One, Jeddo and Johnson Creeks.

2.2 FMC Site Description

FMC currently employs approximately 50 people at its pesticide formulating facility in Middleport. The current Facility (based on property ownership in 2007) consists of approximately 102 acres of land. The 102 acres includes 8.06 acres of property (North Railroad Property) along the northern boundary of the Facility that was purchased from Conrail in May 2002 (see Figure I2.3). The North Railroad Property includes:

- "Northern Ditches," which includes the drainage ditches that run east to west along the north and south sides of the active mainline railroad tracks.
- "Northwest Conrail Area," the eastern portion of which was covered with a temporary soil cover in late 2002 and enclosed by extending the Facility's security fence.
- Approximately 2,700 feet of railroad track and bedding.

At the present time, Falls Road Railroad Company has an operating easement to use and maintain the mainline railroad track, track materials, and appurtenant devices and facilities on the North Railroad Property. The FMC Facility, including the North Railroad Property, is not used for residential purposes and is zoned for industrial use. No plans currently exist to change the zoning of the property. The presence of the active railroad restricts future usages of the North Railroad Property.

FMC also currently owns a strip of land (approximately 0.5 acre) extending into the Roy-Hart School property, as shown on Figure I2.3. This strip of land is part of a parcel that extended through the FMC property along the western limits of the Eastern Surface Impoundment (ESI). Niagara Mohawk (now National Grid) owned this property prior to 1986 and maintained overhead electrical lines on the parcel. FMC purchased the Niagara Mohawk parcel south of the railroad tracks in 1986 to enable construction of the North Site Cover. This transaction included purchase of the Niagara Mohawk parcel north of the railroad tracks. The southern portion of the

former Niagara Mohawk parcel purchased by FMC extends beyond FMC's southeastern fence line.

As shown on Figure I2.3, FMC's security fence currently encompasses approximately 83 acres of land. FMC's pesticide formulating operations are all situated within the security fence. Approximately 20 acres of FMC-owned land is situated outside of FMC's security fence and includes:

- Approximately 0.3 acre of land comprising the Niagara Street entrance from South Vernon Street to the Plant Site.
- A strip of land (approximately 12 feet wide) along the backyards of the residential properties that abut the Facility's western security fence.
- A strip of land (formerly owned by Niagara Mohawk) north of the railroad tracks and extending into the Roy-Hart School property (approximately 0.5 acre).
- Approximately 6.7 acres of land traversed by the mainline railroad tracks that is operated by Falls Road Railroad Company under a permanent easement and the drainage ditch on the north side of the mainline railroad.
- A strip of land outside of the eastern and northeastern Site fencelines.
- The southern portion (approximately 1.3 acre) of the former Niagara Mohawk parcel purchased by FMC in 1986, as described above.
- The southeastern corner of the property, which consists of an overgrown field with clean, imported soil stockpiles.

Figure I2.3 shows the drainage divide at the Site, such that surface water runoff from approximately the "northern half" of the Site is collected and diverted to the WSI and then treated prior to discharge, and surface water runoff from the "southern half" of the Site flows to the State Pollutant Discharge Elimination System- (SPDES-) permitted outfall without treatment.

The "southern half" of the Facility property comprises approximately 39 acres and consists of maintained grassy fields, parking lots, roads, a maintenance building, and office buildings. Pesticide formulating activities are not conducted and historically

pesticide manufacturing or formulating activities were not conducted on this portion of the Facility. As a result of regrading work in the mid-1970s, stormwater from the southern half of the Facility is directed into a series of grassy swales or buried pipelines and combines with the effluent from the Water Treatment Plant (WTP). The stormwater and WTP effluent is then discharged to Tributary One in accordance with the Facility's SPDES permit. Figure I2.8 presents the surface water drainage pattern and the surface characteristics for the Facility.

The "northern half" of the Facility comprises approximately 63 acres. Current and historic pesticide manufacturing/formulation activities occurred within the northern half of the Facility. Pesticides are handled and stored within tanks and enclosed buildings at the Site. This area currently contains several large buildings used for pesticide formulation and warehousing, the WTP and storage tanks, an active and lined nonhazardous water retention basin (WSI), and several railroad spurs. In addition, the Eastern Surface Impoundment (ESI) Fill Area is located at the northeastern portion of the Site. The former ESI was removed from service in the late 1980s and the area has been used for the placement of non-hazardous soil generated from various interim and "Early Action" remedial action projects performed to date (see Section 4).

The majority of the northern half of the Facility is covered with a clay/asphalt cap (the North Site Cover) and buildings. Figure I2.8 shows the limits of the North Site Cover and identifies the current surface characteristics and surface water drainage patterns at the Facility. Section 4.3 describes the construction of the North Site Cover. The clay cover has an established vegetative/grass cover with no bare dirt exposed, except during construction and maintenance activities. Any ground-invasive activities performed on the northern half of the Facility follow the procedures presented in the North Site Cover Operation and Maintenance Program Manual (CRA 1989d), which includes obtaining a plant excavation permit, management of any excavated soils and excavation areas to minimize and control possible surface water runoff, and following other health and safety requirements (i.e., appropriate personal protective equipment).

In 2003, as part of an ICM project (called the 14 Western Residential Properties ICM) that included the removal of soil from the 10 residential properties that abut the Facility's western property boundary, FMC also excavated soil from a buffer strip inside FMC's west fenceline shared with the 10 residential properties. The buffer strip excavation extended approximately 10 feet inside of FMC's security fence and was

backfilled with clay. Section 4.11 further describes the 14 Western Residential Properties ICM.

The North Railroad Property, except for the Northwest Conrail Area and an approximately 15-foot-wide buffer zone along the railroad main line and spurs (i.e., approximately 7.5 feet from the centerline on either side of the tracks), is covered with an engineered surface cover that was installed in 2005 as part of the Phase 1 ICM for the North Railroad Property. Section 4.7.4 describes the Phase 1 ICM activities further and Section 4.7.1 describes the 1987-1988 Interim Remedial Measures (IRM) performed on the Northern Ditches. In 2002, a temporary soil was cover was installed over the eastern portion of the Northwest Conrail Area. A second phase of the ICM for the North Railroad Property is scheduled to be completed in 2008 to install a permanent cover over the Northwest Conrail Area. Figure I2.8 identifies the limits of the Phase 1 ICM cover over the North Railroad Property and the temporary soil cover over a portion of the Northwest Conrail Area.

Stormwater in the northern portion of the Facility (south of the mainline railroad track, with the exception of the western portion of the Northwest Conrail Area) is directed into a series of grassy and/or asphalt-lined swales, or into collection sumps/drains and eventually collected in the WSI or the untreated water storage tanks. The collected stormwater is then treated at the WTP and discharged to Tributary One in accordance with the Facility's SPDES permit. Stormwater runoff from the western portion of the Northwest Conrail Area drains to a catch basin. This catch basin (located on the Northwest Conrail Area) receives the discharge from FMC's SPDES permitted Outfall 001, stormwater runoff from the western portion of the Northwest Conrail Area and stormwater runoff from the back yards of several abutting residential properties that were remediated in 2003 as part of the 14 Western Residential Properties ICM. The discharges to this catch basin drain into the Village of Middleport's storm sewer system that discharges to Tributary One. Stormwater runoff from the eastern portion of the Northwest Conrail Area drains to an asphalt-lined swale and is collected in the WSI.

The reconstructed north ditch situated along the north side of the active mainline railroad tracks receives stormwater runoff from the remediated Phase 1 ICM Area of the North Railroad Property, the properties (i.e., Falls Road Railroad tracks, the Roy-Hart Central School District property, Alfred Street, farm fields and commercial, industrial and residential properties) abutting the northern and eastern boundaries of the North Railroad Property, and a farm field that abuts FMC's eastern fence line. The reconstructed north ditch on the North Railroad Property discharges into the Village of

Middleport's Culvert 105 storm sewer. A new inlet to Culvert 105 was constructed in 2007 as part of the 2007 Early Actions performed on a parcel (previously referred to as the "Wooded Parcel") within the North Commercial/Industrial Area.

2.3 FMC Plant Site History

Prior to its use as a manufacturing facility, the property on which the Facility is located and the adjacent areas were used for agricultural purposes, except for the North Railroad Property. The North Railroad Property is traversed by the mainline railroad tracks, which were constructed in the early to mid 1800's, and has since been used for the operation of the railroad tracks. The Niagara Sprayer Company was originally founded in 1904, and occupied a portion of the North Commercial/Industrial Area north of the railroad tracks and the current Plant Site. Sometime between 1905 and 1911, the Niagara Sprayer Company began manufacturing of agricultural sprayers and possibly some sulfur and lime-based spraying products at facilities situated on the North Commercial/Industrial Area north of the railroad tracks (based on available Sanborn Maps for that period).

Between approximately 1919 and 1921, Niagara Sprayer Company purchased property situated south of the mainline railroad tracks and expanded its manufacturing operations. Activities conducted at the Plant Site (operations south of the mainline railroad tracks) included spraying machines and pesticide manufacturing, formulation and packaging, and research and development. Pesticide manufacturing included operations that utilized chemical reactions to produce pesticide active ingredient(s). Pesticide formulation does not involve chemical reactions, but consists of mixing, blending, and/or diluting pesticide active ingredients produced elsewhere with inert ingredients to produce a commercial product.

The following table presents a chronological summary of the historical company ownership changes, significant operational changes, and major manufacturing operations at the Plant Site (south of the railroad tracks):

Approximate Period	Event
1919 to 1921	Niagara Sprayer Company expanded its manufacturing operations south of the mainline railroad tracks.
1927 to 1946	Niagara Sprayer Company changed its name to Niagara Sprayer and Chemical Corporation (Niagara Sprayer).
1928 to 1974	Manufacturing of lime (i.e., calcium hydroxide, calcium oxide), arsenic, and lead-based pesticides.
1930 to 1983	Manufacturing of sulfur dust products.
1943 to 1946	Food Machinery Corporation purchased controlling interest of the Niagara Sprayer and Chemical Corporation in 1943 and acquired complete interest in the company in 1946.
1955 to 1975	Manufacturing of Dinitrocresol (DNOC).
1957 to 1983	Manufacturing of Dithiocarbamate pesticides (i.e., ambam, polyram, nabam, niacide, thiram, zineb, ziram).
1960's to 1983	FMC performed research and development activities at the parcel of land southwest of the Middleport Plant.
1967 to 1969	Manufacturing of M-4 Thickener (aluminum-based soap).
1969 to 1985	Manufacturing of Carbofuran.
1970 to 1975	Manufacturing of Karbutilate (Tandex).
1985	FMC ceased manufacturing operations at the Middleport Plant.
1985 to present	FMC continues pesticide formulation and packaging operations at the Middleport Plant.

FMC ceased pesticide manufacturing operations at the Middleport Facility in 1985 and has conducted only formulating and packaging operations at this location since that time.

Since 1928, various products other than those manufactured at the Facility have also been used in various quantities for formulation or repackaging. These products include a variety of chlorinated pesticides (e.g., dichlorodiphenyltrichloroethane [DDT], dichlorodiphenyldichloroethene [DDD], endosulfan, benzene hexachloride

[BHC]), organophosphate pesticides (e.g., ethion, malathion, and methyl parathion), and methyl carbamates.

In addition to the pesticide manufacturing and formulation operations, R&D activities for the FMC agricultural products business were conducted at the Facility. One of these activities was a limited-scale research project for the U.S. Department of Defense (DoD) from 1965 to 1967 on the efficacy of herbicides. This project used an estimated total quantity of less than 12 gallons of chemicals under stringent handling controls.

FMC initially conducted R&D activities in buildings and a greenhouse on the northwestern portion of the FMC Plant Site (most of these structures were demolished in the mid 1980s). The R&D activities included development and testing in laboratories and greenhouses and pilot-scale testing of pesticide production and formulations methods. In 1964, FMC constructed two new buildings (Buildings 100 and 102), which contained R&D offices and laboratory facilities, and four to five greenhouses at the southwest corner of the FMC property (referred to as the Former R&D Property) (see Figure I2.3). Laboratory-scale and greenhouse scale testing activities were conducted in the new R&D structures. Pilot-scale testing of pesticide production and formulation methods continued to be performed on the northwestern portion of the Plant Site.

In 1983, the R&D operations at the Middleport Plant were moved to FMC's R&D Center in Princeton, New Jersey. The Former R&D Property, including the two buildings and the associated greenhouses, in the southwest corner of the Plant were decommissioned and then sold in 1985 to Huntingdon Analytical Services. The decommissioning activities included isolation of the storm sewers, sanitary sewers, and other utilities, and removal and/or decontamination of the greenhouses and laboratory areas. Section 2.6.1 further describes the Former R&D Property and the usages of the property after it was sold by FMC.

FMC used small amounts of radiological material from 1971 to 1982 in its research laboratories at the Former R&D Property under a license issued by the New York State Department of Labor (NYSDOL). Typically, this material was used by highly trained technicians and research personnel in tracer studies similar to what a hospital laboratory may perform and was present in laboratory instruments (i.e., gas chromatographic electron capture detector). The FMC R&D facilities were decommissioned following the relocation of operations to Princeton, New Jersey in 1983. Areas where radiological materials were used were decommissioned to the

satisfaction of the NYSDOL. As part of the decommissioning activities, the green houses and their contents and any other equipment that may have handled radiological materials were decontaminated and/or removed and disposed of at an appropriate off-Site disposal facility. Wastes (including any greenhouse soils used in the tracer studies) that were generated from the decommissioning process were managed and transported from the Site for disposal in accordance with applicable requirements. Any remaining useable radiological material was relocated to FMC's Princeton, New Jersey research facility at the time research activities were transferred to that location.

As part of FMC's R&D operations, FMC also owned and operated a 280-acre active commercial farm at 7018 Slayton Settlement Road, Gasport, in Niagara County. The Gasport farm was purchased in the early 1950s and sold in 1985, along with the R&D facilities at the southwest corner of the Plant Site. During FMC's ownership, the Gasport farm was used for commercial production of fruits and vegetables. A portion of the farm, approximately 18%, was used by FMC for evaluation of pesticides. Typically, this would involve small plots along the lines of 10 by 20 feet, with minor amounts of materials applied (grams and ounces) in a single growing season.

A comprehensive list of chemicals, including the above pesticide products, used and/or produced historically at the FMC Middleport Plant was initially developed during a site investigation program conducted in 1985-1987, and presented in the Middleport Site Investigation Final Report (CRA 1987). The list was subsequently refined in 1988 to include degradation substances and impurities associated with materials used and/or produced historically at the FMC Middleport Plant (from the mid-1920s through 1988) based on the best of FMC's knowledge at that time. The revised list is titled Master Compound List and Various Related Lists for Environmental Studies, FMC Corporation, Middleport, New York (dated December 19, 1988), and is referred to as the Master Compound List Document. The Master Compound List Document also contains a list of chemical synonyms, potential degradation products and impurities, and site-specific parameters (SSPL) and analytical procedures to be used for the purposes of conducting environmental studies relative to the FMC Middleport site. In addition, the document describes how the Master Compound List and related lists were developed and presents the NYSDEC's comments on previous drafts of the document and FMC's responses. The Master Compound List Document is presented in Appendix 2A.

By letter dated December 13, 2007, the Agencies requested that FMC evaluate the chemicals identified in a 1967 FMC report (FMC 1967) on the 1965-1967 R&D

testing of herbicides for the DoD, and revise the SSPL if warranted. By letter dated April 30, 2008 FMC submitted to the Agencies the results of its evaluation, which concluded that based on the very miniscule amounts used in the laboratory, in a greenhouse, and in limited field testing, under strict controls, none of the chemicals used in the DoD research study should be added to the SSPL. FMC's April 30, 2008 submittal is currently under review by the Agencies.

The Master Compound List Document identifies the pesticide products manufactured at the Facility and other key compounds used in the manufacturing processes (i.e., acetic acid, ammonia, dimethylamine, ethylene diamine, 7-hydroxybenzofuran, and methylene chloride). FMC discontinued pesticide manufacturing operations in 1985. Since development of the Master Compound List Document, production activities at the Facility have been limited to formulation and packaging of pesticides. Major crop protection products formulated or repackaged at the Facility after completion of the Master Compound List in 1988 include carbofuran, clomazone (Command® and Commence®), bifenthrin, quinclorac (Facet®), cadusafos (Rugby®), fluazinam, flonicamid (Aria®, Beleaf®), and acetamiprid.

2.4 FMC Plant Spill and Air Emissions History

A list of historic accidental spills or releases to the environment is presented in Table 2.1. While detailed records of accidental spills or releases to the environment prior to 1984 are not available, Section 2.4 describes the historic production and disposal of pesticide wastes in lagoons and landfills at the Facility which likely are the most significant release mechanisms to the environment.

Prior to construction of the water treatment plant in 1976-1977 and surface water impoundments in 1978, process wastewater and stormwater were collected in several lagoons and discharged to Tributary One via a buried sewer. Discharge operations were conducted on a controlled basis in order minimize impacts to the receiving stream (e.g., due to ammonia). This buried sewer exited the Facility property at its northwestern boundary and joined with a portion of the Village of Middleport storm sewer system, which discharged to Tributary One under the Francis Street Bridge. (The off-Site section of this buried sewer was removed in 2003 as part of the Western Residential Properties Soil and Former Sewer Removal ICM.) Prior to 1977, stormwater runoff from portions of the southeast and east areas of the Facility also discharged to the Northern Conrail Ditches, which paralleled the mainline railroad tracks and collected stormwater runoff from the tracks and abutting properties. The Northern Conrail Ditches emptied into the Village of Middleport's

storm sewer, Culvert 105, north of the Facility. Culvert 105 discharges into Tributary One downstream of the Village of Middleport sewage treatment plant discharge. Figure I2.9 illustrates the historic waste disposal areas and historic surface water pathways at the Site.

A review of available Agencies' records indicated that between 1962 and 1976 several fish kill incidents occurred in Tributary One, Jeddo Creek, and Johnson Creek. The incidents were reportedly related to discharges from the Niagara Chemical Plant (i.e., FMC) and Loud-Wendell, Inc. plant. The primary causes of the fish kills were allegedly due to the presence of cyanide or ammonia; however, one or more of the following compounds were also identified as potential causes in specific reports:

- Dithiocarbamates.
- Arsenic.
- Zinc.

Appendix 2B presents a summary of these stream pollution reports.

Between April and June 1975, a number of migratory birds (primarily ducks) died as a result of ingestion or other exposure to waters in the eastern process wastewater basin that received wastewater from the dithiocarbamate and carbofuran production areas. Investigation of the bird kill determined that due to a failure in an intermediate treatment system, elevated levels of carbofuran had been discharged into the basin. As an immediate response action, FMC implemented measures, including netting, alarms, and guards, to deter birds from landing in the basin. Subsequently, FMC saponified the water in the basin to decompose carbofuran by adding large amounts of caustic soda. A carbon treatment system was installed so that wastewater from the carbofuran production area could be treated and recycled for use in that area. The wastewater stream from the dithiocarbamate production area was eliminated from discharging to the basin after an evaporator/crystallizer unit was constructed and placed into operation in approximately 1974-1977. FMC closed the eastern process wastewater basin in 1977 following completion of the surface water collection and treatment system (the WSI and WTP), and filled the basin area by grading in 1977-1978.

To meet discharge limits under the National Pollutant Discharge Elimination System (NPDES) permit program, FMC implemented a program to control and monitor levels of pollutants discharging from the Facility. This program included the following:

- In 1973, a Site-wide soil sampling program was conducted on a grid basis (approximately 100-foot centers), with boreholes advanced to bedrock. The samples were analyzed for total arsenic. This information was subsequently used to develop a surface water management program for discharge permitting purposes. Based on the 1973 soil boring findings, the Site was regraded into the northern and southern halves for the purpose of surface water drainage in 1976. Figure I2.3 illustrates the approximate boundary between these northern and southern halves.

- In approximately 1974-1977, an evaporator system was designed, constructed and placed into operation for the pretreatment of wastewaters from the dithiocarbamate process. Discharge of dithiocarbamate process wastewaters to the on-Site process wastewater lagoons also ceased in 1977. Condensate from this process was discharged to the Village sewage treatment plant.

- In response to a bird kill in the eastern process wastewater basin, a granular-activated carbon treatment unit facility was installed in 1975 for the treatment of wastewater (water generated as part of utility and maintenance operations) from the carbofuran manufacturing/formulation area. Treated water was recycled/reused, and excess treated water was discharged to the basin; after 1977, discharge was directed to the surface water collection and treatment system.

- In 1976-1977, a surface water treatment facility and the WSI were constructed for the collection and treatment of stormwater from the northern half of the Facility. In response to several flooding and overflow incidents during the winter and spring of 1977-1978, FMC constructed the Central Surface Impoundment (CSI) and ESI with the approval of the NYSDEC to provide additional retention capacity. In addition, a new, 30-inch-diameter storm sewer pipe was installed to convey treated water and untreated stormwater runoff discharged from the Site, in accordance with a NPDES permit, to Tributary One. The old buried discharge pipe was plugged at the Facility's boundary at that time.

As part of the Facility operations, FMC obtained a variety of permits as required by applicable federal, state, and local environmental rules and regulations. Table 2.2 presents a summary of relevant past environmental-related permits held and/or requested by FMC.

Air emission discharge permits were also obtained for various unit operations such as dryers, evaporator, dust collectors, storage tanks, process thermal oxidizer, and boilers for the manufacturing of arsenic-based and dithiocarbamate pesticides products, and the formulation of pesticides. Appropriate air emission control systems consistent with the time period have been used at the Facility. Table 2.3 summarizes the historic air discharge permits obtained for the Facility. The information included on Table 2.3 was obtained based on review of FMC's and the NYSDEC's historical records.

Information from air permits was used in the investigation of FMC's impact to the environment. In 1987, the NYSDEC performed a study to model fugitive air particulate emissions (i.e., wind-blown dust) from the entire surface of the Facility. In 1996, as part of the RFI, FMC commissioned a review of the Agencies' 1987 air dispersion modeling study and the performance of a new and updated study which modeled historic air releases from arsenic-based product manufacturing operations that occurred from about 1928 through 1974. Environmental Resources Management, Inc. (ERM) performed this study. The results of the review and the new study were submitted to the Agencies in 1996 and are included as Appendix 2C of this report. Appendix 2C presents several versions of the modeled arsenic air deposition contours that were generated by the studies and in response to comments provided by the Agencies in May 1996. Appendix 2C also presents a discussion of the uncertainties associated with the air modeling studies.

2.5 History of Waste Production and Disposal

FMC has limited written records of the wastes generated or disposed of at the Site prior to 1974. However, based on interviews and information that is available, FMC believes and understands that wastes from the pesticide manufacturing, formulating and packaging operations at the Facility were handled in accordance with standard industry practices of the time, which included storage/treatment/disposal in on-Site lagoons or land disposal. FMC believes that the major areas where historic waste disposal occurred at the Facility consist of former wastewater lagoons/basins, a land burial area, and the former arsenical pesticide production area. Figure I2.9 identifies these suspected major areas of historic waste disposal at the Facility. These areas are

summarized in Table 2.4. These major historic disposal areas have also been identified as SWMUs[1]. Table 2.5 lists all SWMUs identified at the Facility and Figure I2.11 identifies the approximate locations of the SWMUs. Section 2.5.2 below discusses the SWMUs identified at the Facility.

Process wastewater generated prior to 1974 was variously stored in former lagoons or basins (SWMUs #3, #5, #6, #7, and #8) at the Facility. These lagoons and basins were located on the northern half of the Facility, as shown on Figure I2.9. Table 2.4 summarizes the wastewater generation processes.

Surface water runoff and wastewater were stored in two settling lagoons (SWMUs #5 and #6) at the northwest corner of the Site from the 1930s until the 1960s. Wastewater containing ammonia was generated as part of the Ambam dithiocarbamate pesticide manufacturing process, which was conducted at the Site from about 1963 to 1983. Ambam is a water-soluble ammonium carbamate intermediate used to manufacture ethylenebisdithiocarbamate (EBDC) fungicide products. The wastewater generated from these processes was stored in two wastewater basins (SWMUs #3 and #7) and in aboveground storage tanks (SWMUs # 9 through #13). Pesticide production/formulation wastes were also buried on the northern half of the Facility until 1970. Areas where former arsenical production activities (i.e., SWMU #1) were located may be contaminated since there was a potential for accidental spills and/or losses of product and raw materials. Soil investigations conducted at the Facility confirm that handling/disposal of pesticide materials were limited to the northern half of the Plant site.

In 1968, a deep well intended for wastewater disposal was installed within the bounds of the eastern process wastewater basin pursuant to the NYSDEC Division of Oil & Gas Permit #68-D1, and with approval of the New York State Department of Health (NYSDOH). The deep well was drilled to a depth of 3,189 feet (0.6 mile) below ground

[1] As used by the NYSDEC in documents such as RCRA permits, a Solid Waste Management Unit (SWMU) includes “any discernible unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of hazardous or solid wastes. Such units include any area at the facility at which solid wastes have been routinely and systematically released.”

surface (bgs), with the open bedrock interval starting at the depth from 2,655 feet bgs. Figure I2.10 illustrates the construction of the deep well. The well was never permitted for use and was never used for waste disposal, and as such, is not considered a SWMU. In 1986, FMC submitted a Plugging and Abandonment (P&A) Plan to the USEPA and NYSDEC to permanently seal the deep well. The well was plugged and permanently sealed from October through December 1986. The well casings were removed or left in-place and perforated, and the upper 2,850 feet of the well was filled in with grout (due to an obstruction at 2,850 feet or a cave-in of the hole below 2,850 feet, the interval between 2,850 feet bgs and 3,189 feet bgs could not be grouted). Documentation associated with the deep well permitting and closure is presented in Appendix 2D.

2.5.1 Solid Waste Management Units

In August 1985, FMC submitted a Continuing Release Statement Related to Solid Waste Management Units to the USEPA that identified 57 SWMUs (FMC 1985). During the performance of the RCRA Facility Assessment (RFA) in 1987-1988, the Agencies identified 53 SWMUs at the Facility based on FMC's August 1985 submittal and Site visits. The SWMUs are listed in Table 2.5 and their approximate locations are shown on Figure I2.11.

Complete descriptions of each unit, including a description of the unit, the location, the status, the period of operation, the types of waste(s) managed in the SWMU, constituents found in the SWMU, media of concern, and a list of references from which the SWMU information was obtained are presented in the RCRA Facility Assessment, Preliminary Review prepared and revised by NYSDEC in January 1988 and on October 7, 1988, respectively, with FMC comments added on May 1,1989 (NYSDEC 1988) (known herein as the 1989 Modified RFA Report). By letter dated September 8, 1989, the NYSDEC acknowledged FMC's 1989 Modified RFA Report and stated that the NYSDEC's 1988 RFA Report and the 1989 Modified RFA Report would be considered in the RFI process.

Changes to the SWMUs listing since the completion of the 1989 Modified RFA Report include the addition of a SWMU and the designation of former SWMU#51 as

an Area of Concern[2] (AOCn). A summary of the changes to the SWMU listing and the status of various SWMUs is as follows:

- The former raw material tank for carbon disulfide was designated as SWMU #51 by the NYSDEC in the RFA Report. However, this tank does not meet the definition of a SWMU since it was not used for management of wastes and no evidence exists of routine or systematic releases. The Agencies have subsequently advised that they consider the former carbon disulfide tank/area to be an AOCn, which includes "areas of potential or suspected contamination as well as actual contamination," and have re-designated the former Carbon Disulfide Tank area as AOCn #1 (Agencies 1998a).

- Since 1988, one additional SWMU (designated SWMU#54-ESI Soil Deposition Area or ESI Fill Area) was created within and adjacent to the ESI and within the area occupied by the former waste water basin at the eastern portion of the Facility (SWMU #3). Soils excavated as part of several IRMs and ICMs performed in some of the nearby study areas from 1996 through 2005 have been placed in the ESI Soil Deposition Area, with temporary soil covers installed over the placed soil. In late 2006, FMC proposed that the eastern portion of the Facility, including the ESI Fill Area, be designated as a Corrective Action Management Unit (CAMU) in accordance with the applicable rules and regulations. FMC submitted an application for designation of a CAMU to the Agencies in March 2008.

- FMC's three surface water impoundments (SWMUs #4, #49, and #50 - WSI, CSI, and ESI, respectively) were determined by the Agencies to be RCRA units subject to interim status requirements under 6 NYCRR Part 373-3 and 40 CFR Part 265. In accordance with an approved closure plan, FMC performed a partial closure of the WSI hazardous waste management unit in 1988 by removal of the accumulated sediments and removal and replacement of the liner. Since that time, FMC has operated this unit for collection and retention of non-hazardous stormwater. Following execution of

[2] Area of Concern (as defined in the Agencies' March 26, 1998 letter to FMC) "includes areas of potential or suspected contamination as well as actual contamination."

the AOC in 1991, operation of the WSI has been authorized as an ICM under the terms of the AOC. FMC ceased use of the CSI in 1988, and closed this unit under an approved closure plan in 1989 by means of excavation and removal of sediment and base material, backfilling with clean soil, cover and vegetation. The ESI was taken out of service and isolated in 1988. The only water entering the ESI since 1988 has been direct precipitation. By agreement with NYSDEC, and documented in the AOC, further closure activities for the ESI have been deferred pending investigation under the RFI and evaluation under a CMS, if a CMS is required. More recently, the area where the ESI was located has been used for placement of remediation wastes (primarily non-hazardous soils) that have been generated in the course of IRM, ICM and "Early Action" projects from 1996-2007, and has now been proposed for inclusion in a Corrective Action Management Unit (CAMU).

- FMC closed five RCRA-regulated hazardous waste container storage areas at the Facility, which had been operated as Interim Status Units pursuant to 6 NYCRR Part 373-3 of the New York State hazardous waste regulations. These five container storage areas are identified as SWMU #21 - Filter Cake Luggers (Area #11), SWMU #26 – Formulations Waste Storage Area (Area #16), SWMU #28 - Specialty Products Storage (Area #18), SWMU #32 - Carbofuran Storage Area (Area #23), and SWMU #40 - Warehouse Storage Area (Area #26). The closure report for these areas was submitted to the NYSDEC on April 3, 1997 and was approved on August 24, 2001. All hazardous waste generated at the Facility is currently disposed of at an appropriate off-Site Treatment, Storage, and Disposal Facility (TSDF) within 90 days of generation in accordance with the applicable large quantity hazardous waste generator rules and regulations.

Many of the 54 SWMUs are located in close proximity to each other and/or are within other SWMUs. As a result, for investigation purpose NYSDEC proposed in the RFA 14 SWMU groups based upon waste types and/or location. This is consistent with Section VI.3.c of the AOC, which reads as follows: "The Respondent may combine units that are adjacent to each other, manage similar wastes, or share the same critical remedial action issue (e.g., groundwater contaminated with the same constituents) into groups for the purposes of the [RFI] investigation." The 14 groups, the SWMUs contained within each group, the location of the group, and the grouping criteria are listed in Table 2.6.

2.5.2 Summary of the RFA Findings

The 1989 Modified RFA Report concluded that hazardous constituents were released to the Site surface water, groundwater, soil, and possibly to the air from the SWMUs at the Site. Groundwater and soil in the northern half of the Facility have been impacted over time, making it difficult to assess releases from individual SWMUs. Prior to 1989, FMC had conducted a number of environmental investigations at the Site. However, it was concluded that an RFI was needed to supplement the existing data to evaluate the extent of releases of hazardous waste or hazardous constituents.

The 1989 Modified RFA Report proposed a “two-phase” investigation approach. The first phase was a detailed evaluation of materials used or produced at the Plant Site and development of a list of “constituents of concern” that would be used for subsequent environmental investigations. The second phase consists of investigations of the SWMU Groups that would utilize the list of “constituents of concern”. As described above, FMC developed the Master Compound List Document in late 1988, as described in Section 2.3. The Master Compound List Document presented a Site-Specific Parameter List (SSPL), which would be used for subsequent environmental investigation programs. The Master Compound List Document describes the criteria used to develop the SSPL and addresses Agencies’ comments on previous drafts of the Master Compound List Document. FMC submitted the Master Compound List Document (see Appendix 2A) to the NYSDEC by letter dated December 19, 1988. Based on a series of exchanges of correspondences between FMC and the Agencies, the SSPL was modified and approved for use by the NYSDEC by letters dated April 28, 1988, June 1, 1989, and June 28, 1989. The SSPL or a subset of the SSPL was subsequently used in the following programs: 1989 CSI Closure, 1989-1992 RCRA Site Groundwater Quality Assessment Monitoring Program, 1990-1993 Off-Site Investigation, and 1993-1997 RFI field sampling and analysis activities. Table 2.7 identifies the parameters on the approved SSPL.

Between 1989 and 1993, FMC and the Agencies discussed the scope of work for the RFI and FMC submitted several drafts of the RFI work plan and other project-specific plans as a result of those discussions and as required after July 1991 under the terms and conditions of the AOC. The Agencies approved the RFI Work Plan (CRA 1993b) in 1993 and FMC began implementation of the approved RFI Work Plan in late 1993, as discussed in Section 1.3.

2.6 Description of Off-Site Study Areas and Background Study Areas

The major off-Site environmental studies (exclusive of groundwater studies) include the 1990-1993 Off-Site Investigation and the RFI field sampling activities performed in 1993-2007. The subsections below describe the off-Site study areas. Section 3.4 discusses the environmental studies performed in the off-Site study areas.

2.6.1 Former R&D Property

The Former R&D Property is the property adjacent to the southwest portion of the Site (Figure I2.3). The Former R&D Property consists of approximately 10.5 acres of land (currently divided into three parcels) situated within the Village of Middleport (a 5.5-acre parcel) and the Town of Royalton (a 2.6-acre parcel and a 2.4-acre parcel). The property is currently zoned for light industrial usages by the Village of Middleport and the Town of Royalton. The Former R&D Property currently is partially enclosed with a security fence. The majority of the property is covered with grass, parking lots or buildings.

FMC's former agricultural products R&D laboratory and offices were located on the property from the early 1960s until 1983. Section 2.3 summarizes FMC's activities on the Former R&D Property. FMC's facilities on the Former R&D Property were constructed in 1964 and consisted of two new buildings (Buildings 100 and 102) and up to five greenhouses. FMC's agricultural chemical R&D offices and laboratories were housed in the two buildings for laboratory-scale testing activities. Pilot-scale testing of pesticide production and formulation methods continued to be performed on the northwestern portion of the Plant Site.

In 1983, the R&D operations at the Plant were moved to FMC's R&D Center in Princeton, New Jersey. In 1983-1985, FMC decommissioned the laboratory and greenhouse facilities situated in the southwest corner of the Plant. The decommissioning activities included separation of utilities from the FMC Plant utilities (i.e., storm sewer, sanitary sewer, water, gas and electric), decontamination of the greenhouses and laboratory areas, and removal of the greenhouses. As discussed in Section 2.3, FMC used small amounts of radiological material from 1971 to 1982 in its research laboratories at the R&D property under a license issued by the NYSDOL. Areas and equipment where this radiological material was used were decommissioned at the time of closure of the laboratory facilities in the early 1980s to the satisfaction of the NYSDOL.

In 1985, FMC sold its R&D property (consisting of Buildings 100 and 102 and the 10.5 acres of associated land) to Huntingdon Analytical Services, Inc. Huntingdon Analytical Services operated a commercial analytical laboratory on the property from 1986 to 1995. On May 9, 1995, Maxim Technologies, Inc. (Maxim) purchased all capital stock of Huntingdon Analytical Services, Inc., which included the property in Middleport. Maxim continued to operate the analytical laboratories until it sold the property in 1996 to 71 Pearce Avenue, Inc., a holding company for Don Enderby Realty, Inc. After 1996, two of the three parcels of land that comprise FMC's Former R&D Property were sold to Dunn and Schoolcraft Transportation LLC. Since 1996, the property has been used for various commercial purposes including a school bus and trucking facility.

Two SWMUs (SWMUs #27 and # 37) are situated on the former FMC R&D property (see Table 2.5). SWMU #27 was an outdoor drum storage area used to store waste solvents from the R&D laboratories and SWMU #37 was an indoor drum storage area used to store waste soils containing pesticides from research activities. Both SWMUs #27 and #37 were closed, decontaminated and verified clean by wipe testing in 1982 in accordance with a closure plan. The closure of both units was certified and approved by the NYSDEC. The RCRA Facility Assessment Preliminary Review (NYSDEC 1988) stated that it was unlikely that any releases occurred from the SWMUs onto the former FMC R&D property. Soil sampling for analysis of volatile organic compounds was performed near SWMU #27 as part of the 1993-1996 RFI sampling and analysis activities. Those sample results did not identify VOC contamination near SWMU #27.

Since the 1970s FMC has performed several environmental studies that included the Former R&D Property. Those studies include the following:

- 1973 Arsenic Soil Boring Program. The 1973 study involved the collection of soil samples down to the top of bedrock on a 100-foot sampling grid for analysis of total arsenic.

- 1979-1980 Investigation of Groundwater Contamination on FMC Property. The study included the installation and sampling of two monitoring wells (currently designated well 3 and A-1) on the property.

- Various routine groundwater hydraulic monitoring events performed in the 1980s and 1990s.

- 1985-1986 Site Investigation, which included the collection and analysis of groundwater samples from the wells on the Former R&D Property.

- 1993-1996 RFI Sampling and Analysis, which included the collection and analysis of soil samples from the Former R&D Property.

- 2002 Sampling Program, which included the collection and analysis of soil samples near the western property boundary of the Former R&D Property.

Detailed discussions of the investigations and associated analytical results for the Former R&D Property will be presented in Volume III of the RFI Report.

2.6.2 Historic Air Deposition Off-Site Study Areas

In 1987, the NYSDEC requested that FMC conduct an extensive investigation of off-Site areas (OSI) that could have been potentially affected by historic Facility operations, as discussed in Section 3.4. In 1987, the NYSDEC performed a study to model air dispersion from historic arsenic manufacturing operations at the Facility. The NYSDOH subsequently sampled surface soils on residential properties north and northwest of the Facility in January 1989 to evaluate off-Site areas that may have been impacted by historic air emission of arsenic from the Facility. The NYSDEC and NYSDOH documented the January 1989 sampling results in reports dated March 27, 1989 and March 1, 1990.

During implementation of the 1993-1997 RFI activities, the Agencies directed FMC to collect additional soil samples to further study soil in off-Site areas that may have been affected by deposition from historic air emissions at the Facility. As discussed in Section 2.4, in 1996 FMC commissioned a review of the Agencies' 1987 air dispersion modeling study and the performance of a new and updated study which modeled historic air releases from arsenic-based product manufacturing operations that occurred from about 1928 through 1974. The results of the review and the new study were submitted to the Agencies in 1996 and are included as Appendix 2C. The air models show that the direction of any historic air depositions from pre-1974 arsenic-based product manufacturing operations at the Facility to be primarily, but not exclusively, toward the north-northeast of the FMC Plant Site. The results of the air models were used as a factor in identifying potential soil sampling areas in subsequent studies intended to delineate the extent of potential FMC-related arsenic in soil around the Facility.

FMC sampled areas around the Plant Site on several occasions (e.g., 1993-1997 RFI, 2002 Additional Sampling Program, September-November 2004 and November-December 2005 RFI sampling) to better characterize the extent of arsenic presence in soil and to delineate the extent of potential impacts from historic FMC operations. The areas sampled through 2007 include approximately 260 residential, agricultural, commercial and industrial properties around the FMC Facility, south of the Erie Canal, east of Tributary One and west of the Niagara/Orleans County line. These properties include the Roy-Hart School Property, agricultural fields to the east and northeast of the Facility, the North Commercial/Industrial Area, and the 14 Western Residential Properties ICM Area. Figure I2.12 identifies the limits of the Historic Air Deposition Off-Site Study Area sampled through 2007 (and also referred to as the Suspected Air Deposition Study Area South of the Erie Canal and West of the Niagara/Orleans County Line). For the data evaluation purposes of the RFI Report, the Historic Air Deposition Off-Site Study Area does not include the FMC Plant Site (including the North Railroad Property), the Former R&D Property, or sediment within Culvert 105 and Tributary One.

In September 2007, the Agencies determined that additional sampling and analysis was necessary north of the Erie Canal and east of the Niagara/Orleans County Line to delineate the northern and eastern extent of potential FMC-related arsenic related to historic air deposition from the Plant Site. The Agencies also determined that this additional work could be performed separately to facilitate completion of RFI Report Volume II and the CMS for the Suspected Air Deposition Study Area South of the Erie Canal and West of the Niagara/Orleans County Line.

Figure I2.5 identifies the current land usages and zoning of the properties within the Suspected Air Deposition Study Area South of the Erie Canal and West of the Niagara/Orleans County Line. Figure I2.6 identifies the historic land usages within and next to the Historic Air Deposition Off-Site Study Area. As discussed in Section 2.1, the historic land use information was based on review of Sanborn Maps, aerial photographs, and information obtained from property owners (see Appendix 2E). Summaries of the current and historic land usages of the properties within the Suspected Air Deposition Study Area South of the Erie Canal and West of the Niagara/Orleans County Line are presented below.

Area east and northeast of the FMC Plant Site – The properties east and northeast of the Plant Site primarily consist of agricultural fields situated outside of the Village of Middleport, within the Town of Royalton. The field that abuts the Facility's eastern property boundary is currently zoned for business uses (see Figure I2.5) and the field

to the northeast of the Plant Site (north of the mainline railroad tracks) is zoned for agricultural usages.

Areas along the public roads are zoned for residential uses. The farm fields are currently used for growing various crops (i.e., hay, alfalfa). Historically, portions of the land had been used for orchards. Farther east and northeast of the agricultural fields are wooded land, farm fields and residential properties.

Area south of the FMC Plant Site – Properties that abut portions of FMC's southern property boundary include a tractor repair shop (named "Service On Site"), an electrical substation, an automobile salvage yard (named "Lake Motors"), and the Former R&D Property (currently occupied by a trucking/transportation company, as described in Section 2.6.1). Farther south, on the south side of Route 31, there are several commercial business and/or light industries (i.e., automobile salvage yard, automobile repair shop, a drive-in theater, and offices), apartment buildings, a church, and a park and a boy scout house (both of which are owned by the Village of Middleport).

Area west of the FMC Plant Site – Properties west of FMC's western property boundary and south of the mainline railroad tracks include the 14 Western Residential Properties ICM Area, other residential properties, and commercial properties. The commercial properties include an automobile garage and electrical substation along the north side of South Street; a former electrical substation lot, a small engine repair shop, and a gas station/convenience store along the west side of South Main Street; and a general contracting business at the corner of Freeman Road and Telegraph Road. The 14 Western Residential Properties ICM Area includes 10 residential properties that are situated on the east side of South Vernon Street and abut FMC's western property boundary, and 4 residential properties that are situated on the west side of South Vernon Street and the east side of South Main Street. Some of the 14 Western Residential Properties are situated within a historic surface water migration pathway from the FMC Facility and are located near FMC's former surface water settling lagoons at the northwest corner of the Facility (see Figure I2.9). In 2003, FMC performed an ICM project that involved the removal of a former outfall sewer from FMC, excavation of soil from the 14 Western Residential Properties and restoration of the ICM area. Approximately 15,000 cubic yards of soil was removed from the ICM excavation area (which encompassed approximately 4.75 acres of land). Section 4.11 further describes the ICM performed in 2003 on the 14 Western Residential Properties ICM Area.

Area north of the FMC Plant Site – Properties that abut FMC's northern property boundary (north of the mainline railroad tracks) include an agricultural field, the Roy-Hart School Property, the southern end of Alfred Street, and the North Commercial/Industrial Area. The Roy-Hart School Property and the North Commercial/Industrial Area are described below. The study area farther north of these properties and south of the Erie Canal primarily consists of residential properties and businesses (i.e., funeral home, stores, restaurants). Historical businesses (see Figure I2.6) include several lumber yards located along the south side of the Erie Canal and between Vernon Street and Washington Street (as depicted on the Sanborn Maps dated 1894, 1889, 1900, 1905, 1911, 1920, and 1931). In 2007, FMC proposed remediation of 13 residential properties (P-Block) situated along the south side of Park Avenue, between Maple Avenue and Alfred Street as part of the 2007 Early Actions which were approved by the Agencies under the ICM provisions in the AOC (see Section 4.12). Soils from 10 of the 13 P-Block properties were removed and the excavated areas were restored in 2007. Access permission could not be obtained in 2007 from the remaining three P-Block properties.

North Commercial/Industrial Area – This area abuts FMC's northern property boundary, west of Alfred Street, and consists of commercial and industrial business properties (seven parcels) and one residential property (at the corner of Vernon Street and Cemetery Street). The North Commercial/Industrial Area currently consists of four parcels of industrial land (zoned light industrial) east of Maple Avenue and three parcels of commercial land (zoned business uses) situated along the south side of Elizabeth Street. The easternmost industrial parcel was a former vacant wooded/overgrown area (otherwise referenced as the Wooded Parcel) with a burned-down structure. A buried section of the Culvert 105 storm sewer traverses this parcel. This parcel was remediated by FMC as part of the 2007 Early Actions (see Section 4.12). The 2007 Early Actions, which were approved by the Agencies under the ICM provisions of the AOC, included soil removal, construction of a 2-foot thick to 4-foot thick engineered soil cover system over the parcel, extension of the North Ditch (which runs along the north side of the mainline railroad) and installation of a new section of the buried Culvert 105 storm sewer. Upon agreement of the property owner, it is anticipated that property usage restrictions will be established for the parcel pursuant to a legal mechanism, in order to prevent exposure to remaining contaminants and to allow for continued maintenance of the soil cover system. The remaining three industrial parcels (east of Maple Avenue) are currently occupied by vacant buildings and a machine shop (Specialty Grinding). The commercial parcels

along the south side of Elizabeth Street are currently occupied by a car washing business, a former coal shed, and a vacant lot.

Review of the historic Sanborn maps indicates that historic usages of the properties within the area include coal storage, machine shops, train depot, and feed mill on the westernmost parcels (west of Maple Avenue), a cemetery, can manufacturer, agricultural/orchard sprayer equipment manufacturer (i.e., Niagara Sprayer), pump manufacturer (i.e., American Sigma, Inc.) and metal fabrication companies (i.e., Norco Corporation, Specialty Grinding) on the three parcels situated at the corner of Elizabeth Street and Maple Avenue; and an orchard and a vinegar works company on the easternmost parcel. Niagara Sprayer Company and the Niagara Sprayer and Chemical Corporation began manufacturing spraying machine and formulated sulfur-based spraying solutions on the parcels situated east of Maple Avenue between 1905 and 1911 (based on available Sanborn maps). FMC acquired these parcels as part of its acquisition of Niagara Sprayer and Chemical Corporation in 1943-1946. FMC sold off portions of the former Niagara Sprayer land (then vacant and no longer in use) within the North Commercial/Industrial Area in the 1950s and 1960s.

Roy-Hart School Property - The Roy-Hart Middle School (grades 5-8) and High School (grades 9-12) property abuts the FMC northern property boundary, north of the mainline railroad tracks. The 2006 layout of the school property and significant features (i.e., storage tank(s) and play areas) on the property are shown on Figure I2.13. The school buildings are currently heated by gas, but historically used heating oil. By 2006, one aboveground gasoline storage tank remains on the school property (see Figure I2.13). Figure I2.13 depicts historic fuel oil and gasoline underground and aboveground storage tank locations at the school property (based on drawings provided by the Roy-Hart School District and included in Appendix 2E).

Most of the northern half of the school property is currently covered with buildings, paved roads and parking areas, and sod. The school athletic facilities (i.e., all-weather track, football field, bleachers, baseball fields, and soccer/lacrosse fields), maintenance office building and former school bus maintenance building (the school bus maintenance activities were moved off the school property in late 2005) occupy the southern half of the property. The southern property boundary shared by the Roy-Hart School District and FMC is mostly situated south of a chain-link fence constructed by FMC for the school district (see Figure I2.13).

The original school building comprises what is now the northern portion of the High School building and was constructed in 1911. The area occupied by the current

football and track and the area occupied by the current Middle School was historically used as an orchard and/or farmland. The two areas were purchased by the school district between 1934 and 1946. The current Middle School building was originally constructed in 1957 with additions constructed later in 1962-1963. From 1957 to 2005, the current Middle School building was used as an elementary school (Grades K-6). Major expansions of the High School buildings and the associated athletic facilities (i.e., football field and track) occurred in approximately 1938, 1949, 1952, 1962, 1984, 1997, and 1999-2000 (as part of the School Football Field Area ICM) The school bus maintenance garage was constructed in approximately 1962 to 1964 and was used for bus maintenance activities since the 1960s to 2005. In 2005, the school bus maintenance activities were moved off the school property to a new building in Gasport. The school bus maintenance building is currently (as of 2006) used for storage of maintenance supplies, chemicals, equipment and materials for the school district.

Since the 1970s, FMC and the Agencies have variously conducted a number of environmental studies, one IRM, and two ICMs on the school property. Those activities were as follows:

- 1981-1983: various groundwater investigations north of the Plant Site.
- 1985-1987: various soil sampling and groundwater sampling on the school property.
- 1985-1986: Site Investigation, which included the collection and analysis of groundwater samples on the school property.
- 1988-present: routine and ongoing groundwater monitoring programs, as required under RCRA and the AOC.
- 1993-1996: RFI Sampling and Analysis, which included the collection and analysis of soil samples from the Roy-Hart School District Property.
- 1996: Bleacher Area IRM.
- 1998: USEPA Baseline Human Health Risk Assessment.
- 1999-2000: School Football Field Area ICM.

- 2005: Phase 1 North Railroad Property ICM (work extended onto a portion of the Roy-Hart School Property).

- 2005: Off-Site Soil Gas Study.

- 2006-2007: Additional soil gas/vapor intrusion studies, including indoor air, crawl space air, and sub-slab vapor sampling, and additional groundwater investigations.

In the course of these studies, over 517 groundwater samples from approximately 19 monitoring wells, and over 2,317 soil samples have been collected from the Roy-Hart School Property from the 1980s through 2005. In April 2006, FMC installed six additional monitoring wells (3 overburden and 3 shallow bedrock wells) on the school property as part of an investigation of VOCs in groundwater beneath the school property. The six new wells and other existing monitoring wells on and near the school property were sampled for analysis of VOCs and other parameters in May-June 2006, as described in the approved VOC Groundwater Investigation Work Plan (Geomatrix 2006).

In 1996, FMC removed approximately 2,200 cubic yards of impacted soil from the area behind the southernmost bleachers as part of an IRM. In 1999 through 2000, FMC performed an ICM project that involved the removal of approximately 39,000 cubic yards of impacted soil from the southwestern portion of the school property, backfilling the excavated areas with clean imported soils, and construction of a new football field, all-weather track, lighting for the field, bleachers, field house, and a chain link fence around the track/football field. Sections 4.9 and 4.10 further describe the remedial activities performed on the school property.

In November and December 2003, FMC extended the existing fence around the south side of the football field and track area farther to the east (to the school's eastern fence) and to the west beyond the Culvert 105 sewer inlet. The fence was intended to limit access to the drainage ditch that runs along the north side of the railroad track "North Ditch" and the North Railroad Property. The fence is situated on the Roy-Hart School property, the Village of Middleport property at the south end of Alfred Street, and the easternmost parcel of the North Commercial/Industrial Area.

In 2005, FMC performed the Phase 1 North Railroad Property ICM. The Phase 1 ICM project included reconstruction of the North Ditch. Portions of the north drainage ditch are situated on property owned by the Roy-Hart School. Remediation of the

North Ditch involved excavation of two feet of soil (north of the mainline railroad track and onto the School Property to the School Property's southern fenceline) and construction of a 2-foot thick cover system. Section 4.7.4 further describes the Phase 1 North Railroad Property ICM.

2.6.3 Culvert 105 and Flood Zone

Culvert 105 is a municipal stormwater drainageway (approximately 6,600 feet or 1.25 miles in length) that consists of a series of open swales and buried sewer pipes which collect stormwater runoff from areas in the eastern part of the Village of Middleport, including, at least historically, portions of the FMC Plant Site. The inlet to Culvert 105 is located at the western end of the North Ditch that runs along the north side of the mainline railroad track. The outlet of Culvert 105 discharges to Tributary One immediately north-northeast of the Middleport Sewage Treatment Plant. Figure I2.14 depicts the current alignment of Culvert 105 north and south of the Canal. As of the end of 2007, Culvert 105 consists of a buried sewer system south of Sleeper Street. North of Sleeper Street, Culvert 105 consists of buried sewer and open ditches.

Much of Culvert 105 is owned by the Village of Middleport and is part of the Village's storm sewer system. The New York State Canal Corporation (a subsidiary of the New York State Thruway Authority) owns and maintains the section of Culvert 105 that runs beneath the Erie Canal. Sections of Culvert 105 have reportedly been historically cleaned out and/or excavated to promote drainage (i.e., the section next to the Middleport Sewage Treatment Plant and the section which runs beneath the Erie Canal). In addition, open sections of Culvert 105 reportedly have been historically converted to buried sewer pipe over time. Records of the clean-outs and the conversions of open swale sections to buried sewer are not available.

Culvert 105 south of the Canal currently receives runoff from private properties (i.e., residential properties, the North Commercial/Industrial Area, and businesses) and public streets south of the Canal, east of Main Street and west of Alfred Street and the North Ditch (which runs along the north side of the mainline railroad track). The North Ditch currently receives stormwater from the Roy-Hart School Property, farm fields east and northeast of the FMC Plant Site, Alfred Street, and any stormwater that falls on the portion of the remediated North Railroad Property situated north of the mainline railroad track. Stormwater runoff from the southern half of the North Railroad Property and from the FMC Plant Site currently does not drain to the north ditch and Culvert 105.

North of the Canal, Culvert 105 (consisting of open drainage ditches and buried storm sewer pipe) receives stormwater runoff from residential and business properties, vacant land, a park, public streets, and farm fields. In the past, runoff from former orchards and green houses drained into Culvert 105 north of the Canal (see Figure I2.6).

Surface water is present in the open ditches of Culvert 105 during and immediately after major rain events and the spring thaw. The open ditch sections of Culvert 105 are approximately 2 to 4 feet in width, and 2 to 4 feet deep. The buried sections of Culvert 105 consist of 24-inch-diameter (with some 36-inch-diameter) sewer pipe sections of various constructions (i.e., tile, metal, plastic, stone, and concrete). Records on the history and construction of Culvert 105 storm sewer are not available. In early 2004, FMC commissioned a video inspection and mapping of the buried sections of Culvert 105 south of the Canal. The results of the inspection and mapping activities are presented in a report entitled Culvert 105 Video Inspection Results (BBL 2004b), which was submitted to the Agencies.

Prior to 1977, stormwater runoff from a portion of the FMC Facility discharged to the drainage ditches (Northern Conrail Ditches) that ran along the north and south sides of the mainline railroad tracks which emptied into Culvert 105 (see Figure I2.9). In 1987 and 1988, FMC performed the Northern Ditches Restoration IRM program to address elevated arsenic concentrations in surface soil/sediments within the invert of the Northern Conrail Ditches. Section 4.7.1 further describes the IRM. In 2005, FMC completed the Phase 1 ICM project for the FMC-owned North Railroad Property which involved the excavation of impacted soils, the regrading and re-direction of drainage areas to the Culvert 105 inlet, and the construction of a containment cover system over the Phase 1 ICM area, including the drainage ditches. Section 4.7.4 further describes the 2005 Phase 1 ICM project.

In 2007, FMC performed remedial activities as part of the 2007 Early Actions (see Section 4.12) in portions of Culvert 105 between Sleeper Street and the North Ditch. The 2007 Early Actions included removal of sediments and/or flushing of portions of Culvert 105 south of Sleeper Street; abandonment of an inlet section of Culvert 105 and installation of a new section of buried sewer pipe on the easternmost parcel (formerly a wooded/overgrown area) of the North Commercial/Industrial Area; construction of a 2-foot thick soil cover system over the easternmost parcel of the North Commercial/Industrial Area; excavation of soil along open swale sections between Sleeper Street and the Erie Canal; and installation of new storm sewer pipes and manholes in the former open swale sections.

2.6.4 Tributary One

Tributary One of Jeddo Creek feeds into the Middleport Reservoir (within the Town of Royalton) south of the Village of Middleport and runs northerly from the Reservoir approximately 6.75 miles through the Town of Royalton, the Village of Middleport, the Town of Hartland, and into the Town of Ridgeway until its confluence with Jeddo Creek. Tributary One discharges into Jeddo Creek south of Route 104 in the Town of Ridgeway. Figure I2.1 identifies the location of Tributary One and Jeddo Creek. Figure I2.15 identifies Tributary One north of Pearson Road, Jeddo and Johnson Creeks, and other contributing drainageways.

Prior to 1990, the NYSDEC classified Tributary One as Class D surface water. A Class D stream is classified as follows (6NYCRR Part 701):

> *The best usage of Class D water is fishing. Due to such natural conditions as intermittency of flow, water conditions not conducive to propagation of game fishery or stream bed conditions, the waters will not support fish propagation. These waters shall be suitable for fish survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.*

In the early 1990s, the NYSDEC reclassified Tributary One as Class C surface water which is defined by the NYSDEC Water Quality Regulation as (6NYCRR Part 701):

> *The best usage of Class C waters is fishing. These waters shall be suitable for fish propagation and survival. The water quality shall be suitable for primary and secondary recreation, although other factors may limit the use for these purposes.*

The width of Tributary One ranges from approximately 5 to 30 feet and its average depth is between 0.5 and 1 foot. The banks of Tributary One are highly variable, ranging from less than 1 foot in height in low lying areas to more than 4 to 5 feet in highly modified areas within the Village of Middleport. Parts of the stream bank have riprap or other protective devices in some of the residential area through which the tributary flows. The bottom characteristics of Tributary One vary and range from almost 100% bedrock to sediments with a substantial fraction of fine-grained material.

For the purposes of the RFI, Tributary One and its floodplain was divided into two study areas: Tributary One South of Pearson/Stone Roads; and Tributary One North of

Pearson Road and east of Stone Road. These two study areas are further described below. The section of Tributary One south of Francis Street has been studied to characterize upstream or background conditions in the creek.

2.6.4.1 Tributary One South of Pearson Road and West of Stone Road

The RFI study area referred to as "Tributary One South of Pearson/Stone Roads" consists of the section of Tributary One (approximately 3.75 miles in length) starting from the Middleport Reservoir to the west side of Stone Road (see Figure I2.1). The study area includes the creek bed and adjacent 100-year floodplain areas along the creek. Figure I2.14 depicts the 100-year floodplain (determined based on applicable Federal Emergency Management Agency [FEMA] flood insurance maps) for Tributary One South of Pearson/Stone Roads.

FMC's existing SPDES-permitted Outfall (Outfall 001) discharges into Tributary One north of the Francis Street Bridge and south of the railway lines. The discharge consists of treated water from the WTP (surface water runoff from the northern half of the Facility and extracted groundwater) and untreated surface water runoff from the southern half of the Facility. Stormwater from a portion of the Northwest Conrail Area, the Culvert 105 storm sewer, Village and Town streets, residential properties, commercial and business properties, existing and former farm fields and orchards currently discharges into Tributary One South of Pearson/Stone Roads. In addition, the Middleport Sewage Treatment Plant also discharges to Tributary One.

North of the Erie Canal, flow in Tributary One is supplemented with water discharged from the Canal during the summer and fall seasons (when the Canal is full). FMC's flow monitoring station and weir is located in Tributary One north of Church Street and south of the Erie Canal. Current Middleport businesses located adjacent to Tributary One include an antique store, an appliance store, and a battery recycler. Currently, existing agricultural fields, wooded and residential properties are situated along and drain to Tributary One. In addition, a trailer park is also situated along Tributary One on the south side of Sherman Road. Figure 2.5 identifies the current zoning for areas along Tributary One south of Pearson/Stone Roads.

Figure 2.6 identifies historic land uses for areas along Tributary One south of Pearson/Stone Roads. Historic businesses located adjacent to Tributary One included a coal storage yard and lumberyard, Loud-Wendell, Inc. plant (manufacturer of saw blades), flour and paper mills, stave mill, and boat dry docks. In addition, many former orchards and agricultural fields have been historically cultivated

adjacent to Tributary One and or drained into Tributary One. In the late 1800s and early 1900s, several mill ponds existed as part of the creek at the following locations (CRA 2003d):

- Approximately halfway between Route 31 and the railroad (since filled in, except for the creek bed).
- Between the railroad and Church Street (since filled in, except for the creek bed).
- Between Church Street and the Canal (since filled in, except for the creek bed).
- South of Sherman Road (since filled in, except for the creek bed).
- Between Sherman and Chase Roads. Between Chase and Pearson Roads.

Prior to 1977, FMC's discharge point to Tributary One was located beneath the Francis Street Bridge. FMC and other industries (i.e., Loud-Wendel Company; Niagara Foods, Inc.) located in Middleport, including the Middleport Sewage Treatment Plant, have historically discharged stormwater or wastewater to Tributary One. Between 1962 and 1976, several discharge incidents relative to FMC and Loud-Wendel were investigated by the NYSDEC (CRA 2003d). Based on review of historical Sanborn maps (see Appendix 2E), former industries located along Tributary One South of Pearson/Stone Roads that may have contributed to discharges to Tributary One include a dry dock, stave/saw mills, paper mills, flour mills, fruit and vegetable canning/packaging operations, stave mill, copper shop, lumber and coal yards, food/feed/cider mills, and machine shops.

Some low-lying forested/shrub areas along Tributary One north of the Canal may support wetland habitats and serve as a flood control/plain for Tributary One. These areas include the former Mill Pond between Sherman and Chase Roads, the former Mill Pond north of Chase Roads and south of Pearson Roads, and the areas along Pearson, downstream of the Middleport Sewage Treatment Plant.

2.6.4.2 Tributary One North of Pearson Road and East of Stone Road

Tributary One North of Pearson Road and East of Stone Road consists of the section of Tributary One (approximately 3 miles in length) starting from the west side of

Stone Road (see Figure I2.15) to the confluence with Jeddo Creek. The study area includes the creek bed and adjacent 100-year floodplain areas along the creek. Figure I2.16 depicts the 100-year floodplain (determined based on applicable FEMA flood insurance maps), current land usages and zoning, and historical orchard locations for the Tributary One North of Pearson Road study area.

Tributary One North of Pearson Road is situated within the Towns of Hartland and Ridgeway, and flows predominantly south to north for approximately 3.5 miles from Stone Road to its confluence with Jeddo Creek near the intersection of Route 104 (Ridge Road). Flow rates in Tributary One north of Pearson Road are variable, as the tributary is supplemented by surface-water runoff from numerous sources (i.e., drainage swales from agricultural areas, Culvert 104 storm sewer which runs below the Erie Canal, east of Culvert 105) as well as by the Erie Canal during the summer months.

Nearly all of the land located within the floodplain of Tributary One north of Pearson Road to its confluence with Jeddo Creek is currently zoned for agricultural use, with certain properties identified as having historical orchard operations within a portion of the properties. Some sections of Tributary One floodplain properties east of Stone Roads are currently zoned for residential use.

Additional information on the physical characteristics of Tributary One East of Stone Road were obtained as part of sampling activities performed in 2006 and will be reported in RFI Report Volume VI - Tributary One and Floodplain North of Pearson/Stone Roads.

2.6.5 Jeddo Creek and Tributaries

Jeddo Creek is located several miles east of the Facility and generally flows in a northerly direction through wooded areas, agricultural fields, current or historical orchards until its confluence with Johnson Creek, north of Mill Road. Tributary One joins Jeddo Creek approximately four miles north-northeast of the Village of Middleport (see Figure I2.16) on the south side of Route 104, within the Town of Ridgeway. Jeddo Creek is classified by the NYSDEC as a Class C stream. The floodplain for Jeddo Creek was not mapped on the FEMA flood insurance maps.

The section of Jeddo Creek (and associated floodplain) upstream of its confluence with Tributary One has been studied to characterize upstream or background conditions for the creek. The section of Jeddo Creek downstream of its confluence

with Tributary One has been studied further to characterize any potential impacts from historical surface water discharges from the FMC Middleport Plant Site.

Jeddo Creek upstream of its confluence with Tributary One receives stormwater drainage from a number of sources, including contributing drainage swales which run through wooded, agricultural and orchard areas. Jeddo Creek also receives treated groundwater discharges and surface water runoff from the FMC Dublin Road Site and stormwater runoff from the Middleport municipal landfill (adjacent to the FMC Dublin Road Site). Both the FMC Dublin Road Site and the Middleport municipal landfill are located approximately 2.5 miles east of Middleport on Dublin Road, which is on the north side of the Canal and west of Jeddo Creek.

The land along Jeddo Creek downstream of its confluence with Tributary One is currently zoned for residential and/or agricultural usages. North of Route 104, Jeddo Creek runs through wooded and agricultural areas and historical orchard areas. A privately owned camping park is located along Jeddo Creek, south of Mill Road, off of County Line Road. Figure I2.7 depicts the current zoning and Figure I2.16 identifies the approximate historical orchard locations for the Jeddo Creek study area from its confluence with Tributary One to its confluence with Johnson Creek.

Additional information on the physical characteristics of Jeddo Creek downstream of its confluence with Tributary One were obtained as part of sampling activities performed in 2006 and will be reported in RFI Report Volume VI - Tributary One and Floodplain North of Pearson/Stone Roads.

2.6.6 Johnson Creek and Tributaries

Johnson Creek is located approximately six miles north of the Village of Middleport. Johnson Creek is classified by the NYSDEC as a Class C stream. Jeddo Creek flows into Johnson Creek on the north side of Mill Road.

Johnson Creek upstream of its confluence with Jeddo Creek was studied in 2006 to characterize upstream or background conditions (i.e., the upstream portion of the creek would not have received any surface water discharges from the FMC Middleport Plant Site). The section of Johnson Creek downstream of its confluence with Jeddo Creek (approximately from County Line Road to Marshall Road) was studied in 2006 to characterize any potential impacts from historical surface water discharges from the FMC Middleport Plant Site.

Additional information on the physical characteristics of Johnson Creek was obtained as part of sampling activities performed in 2006 and will be reported in RFI Report Volume VII - Jeddo Creek, Johnson Creek, and Floodplains.

2.6.7 Erie Canal

The Erie Canal runs east-west through the Village of Middleport and is located north of the Facility (see Figure I2.2). The section of Erie Canal which traverses the Village of Middleport is primarily used for recreational purposes during the warm season and is drained annually from November to May. Water from the Erie Canal supplements the flow in Tributary One during the dry season to prevent stagnation in the section of Tributary One north of the canal. The Erie Canal was studied as part of the 1990-1993 Off-Site Investigation to help characterize area background surface water and sediment quality.

The Erie Canal is classified by the NYSDEC as a Class C fresh surface water.

2.6.8 East Branch of Eighteen Mile Creek

The Gasport portion of the East Branch of Eighteen Mile Creek is located approximately five miles west of the Village of Middleport and generally flows in a northerly direction through the east side of the Village of Gasport (see Figure I2.1). The section of the East Branch Eighteen Mile Creek that is located between Gasport Road and the outlet of Mirror Lake (south side of the Erie Canal) is classified by the NYSDEC as a Class B stream. The section of the East Branch Eighteen Mile Creek that is located downstream of the outlet of Mirror Lake (south side of the Erie Canal) to Ridge Road (Route 104) is classified by the NYSDEC as a Class C stream.

The East Branch of Eighteen Mile Creek has not received any discharges from the FMC Middleport Plant Site and was studied as part of the 1990-1993 Off-Site Investigation to help characterize area background surface water and sediment quality.

2.6.9 Gasport Properties

In 1985, 1989, 1990, and 2002, FMC performed several sampling and analysis studies of various properties within and near Gasport (approximately five miles west of the Village of Middleport) to better establish background soil, sediment and surface water conditions for areas that have not been potentially impacted from

current or historical operations at the FMC Middleport plant Site. These studies included the following:

- 1985-1986 Surface Soil Sampling & Analysis Program of the Royalton-Hartland and Gasport School Properties.
- 1989 Gasport Orchard Property.[3]
- 1990-1993 Off-Site Investigation.
- 2002-2003 Gasport Soil Background Study.

Since 2003, the Agencies have used the soil sampling data from 2002-2003 Gasport Soil Background Study to establish background soil arsenic levels for purposes of RFI delineation studies. Section 6 further describes the background soil data collected from the Gasport properties.

[3] Name of property withheld for confidentiality purposes.

3. Previous and Ongoing Investigations and Monitoring Programs

A number of environmental investigations and monitoring programs have been conducted at and around the Facility since 1973. These programs were designed to evaluate surface, subsurface, and hydrogeologic conditions for the nature and extent of hazardous constituents potentially attributable to releases from historical operations at the Facility and to monitor the corrective measures which have been implemented to date. A list of the major investigation/monitoring activities conducted is presented in Table 3.1. Appendix 3A includes a list of events relative to environmental conditions at the Plant Site through March 2008. Over the years, FMC has generated over 300 reports for the NYSDEC, USEPA, NYSDOH and other regulatory agencies on environmental programs related to the Facility. Appendix 3A includes a list of these reports generated through March 2008.

Sections 3.2, 3.3, and 3.4 below summarize the key environmental studies performed at the FMC Plant Site (including the North Railroad Property), groundwater, and off-Site Study areas, respectively. The studies and remediation performed after 1991 were performed in accordance with the terms and conditions of the 1991 AOC.

In addition to the environmental investigations, the Agencies performed public health studies of the community and the Roy-Hart School Property in the mid 1980s. The Agencies also performed a public health risk assessment of the Roy-Hart School Property in 1998. Section 3.5 discusses those studies. In 2003, FMC commissioned the performance of an environmental exposure study of the Middleport community. Section 3.6 describes the 2003 study.

In 1995 and 2005, FMC conducted Site-specific studies using soil collected from several off-Site study areas to estimate arsenic bioavailability in soil from Middleport to support any future public health risk assessments that may be performed. Section 3.7 summarizes the Site-specific studies.

In addition to the Site-related investigative studies, FMC performed sampling and analysis of soil background areas that could not have been impacted by operations at the Plant Site. Data from the soil background studies were used to help establish background conditions in the area. The background data will be used to help determine if the RFI objectives have been adequately met (i.e., delineation of the extent of releases of hazardous waste or hazardous constituents). Section 6 discusses the background studies and presents the data obtained to date.

3.1 FMC Plant Site

In 1973, an extensive series of boreholes was advanced to bedrock and sampled in a grid network (at approximately 100-foot intervals) over the entire Facility. Approximately 2,230 soil samples were collected at 2-foot intervals and over 2,000 soil sample analyses for arsenic were conducted. The information resulting from this program was later used along with knowledge that past manufacturing and waste disposal activities had occurred only on the northern portion of the Facility to divide the Facility into a northern and a southern "half" for purposes of collection and treatment of surface water runoff (see Figure I2.3). The Facility was regraded to segregate the impacted surface runoff (from the northern half of the Facility) from the surface runoff from the southern half of the Facility as part of the program to comply with NPDES permit limits in about 1976.

In 1986, as part of a comprehensive Site Investigation (SI) program, approximately 50 soil samples were collected at the Facility for analyses of 51 parameters which resulted in over 2,500 chemical analyses. In addition, surface water and sediment samples were collected from the Plant Site drainage swales and from the Northern Ditches (the ditches that ran along the north and south sides of the mainline railroad tracks). The SI confirmed that arsenic was the most predominant constituent in the Site soils, sediments and surface water.

Beginning in 1987, in preparation of the closure of the three surface water impoundments, FMC implemented the pre-closure activities, which included a program to cover the northern half of the Facility. The North Site Cover isolated the impacted soils in the northern half of the Facility, reduced off-Site migration of soil constituents via the surface water and air pathways, and minimized the potential for any casual direct contact of potentially impacted soils by visitors or workers at the Facility. Surface water runoff from the North Site Cover is collected in the WSI prior to treatment and discharge to Tributary One pursuant to the Facility's SPDES permit. Surface water runoff into the WSI is routinely monitored. The data from this monitoring program is presented in FMC's quarterly progress reports required by the AOC.

Under the terms and conditions of the AOC, FMC developed and implemented the approved 1993 RFI Work Plan, which consisted of soil and groundwater sampling activities. In 1993, as part of the RFI, approximately 40 soil samples were collected from within or adjacent to the SWMU Groups at the Facility and at the Former R&D Property for analysis of approximately 80 SSPL test parameters (see Table 2.7),

which resulted in over 3,000 chemical analyses. The results of this study confirmed that arsenic was the predominant and most pervasive soil constituent at the Facility. Based on the RFI results, a Soil Indicator Parameter List consisting of arsenic, lead, ETU, and chlorinated pesticides was developed. The results of these soil samples were submitted to the Agencies in the RFI Summary Report (CRA 1994b) in August 1994. The Agencies provided comments on the RFI Summary Report and directed additional soil sampling in areas on- and off-Site by letter dated April 12, 1995 (Agencies 1995a). FMC provided final responses to the Agencies by letter dated July 19, 1995 (FMC 1995b). This submittal also provided a proposed scope of work for an RFI Phase II Soil Investigation. In September and December 1995, FMC performed the proposed RFI Phase II Soil Investigation activities, including the collection of 23 additional soil samples from on- and off-Site locations for analyses of the Soil Indicator Parameter List. In July 1996, FMC collected additional on- and off-Site soil samples to supplement the existing soil database for the Plant Site.

In May 2002, FMC purchased the North Railroad Property from Conrail. Prior to and after the purchase of the North Railroad Property, FMC collected and analyzed soil, sediment, and surface water samples from the North Railroad Property as part of the following programs:

- 1985-1986 Site Investigation.
- 1987-1988 Northern Ditches Restoration IRM Program.
- 1990-1993 Off-Site Investigation.
- 1993-1998 RFI.
- 2002 Sampling Program.
- 2004 North Railroad Property RFI Soil Sampling and Analysis, as specified in the North Railroad Property RFI/CMS Work Plan, dated October 2003.
- Spring 2005 surface water run-on sampling and analysis, as part of the Phase 1 ICM for the North Railroad Property.

These studies are further discussed in Section 3.4. The results of the studies conducted through 2004 are summarized in the Technical Report on Data Sufficiency for the North Railroad Property (BBL 2005b), which was approved by the Agencies,

by letter dated June 27, 2005. One of the conclusions in the Data Sufficiency Report is that there are sufficient data to evaluate remedial alternatives for the North Railroad Property. As such, FMC proposed remedial alternatives for the North Railroad Property in late 2004.

The Agencies subsequently communicated their determination that an ICM was necessary on the North Railroad Property by letter dated January 18, 2005. FMC agreed to perform an ICM for the North Railroad Property by letter dated February 22, 2005 and proposed that the ICM consist of two phases. The first phase would be performed on the portion of the North Railroad Property, exclusive of the Northwest Conrail Area. The second phase would be performed on the Northwest Conrail Area, which had been enclosed with a security fence and a portion covered with a clean soil cover in 2002 (see Section 4.7.2).

FMC completed the Phase 1 ICM for the North Railroad Property in June through September 2005 (which included construction of an engineered cover system). The completed Phase 1 ICM activities are described in Section 4.7.4 of this report and in the Final Construction Report for the North Railroad Property Phase 1 Interim Corrective Measures (BBL 2006c). FMC also prepared and submitted the Phase 1 ICM OM&M Plan (BBL 2006e), which was approved by the Agencies by letter dated June 14, 2006. Implementation of the approved operations, maintenance and monitoring activities began in July 2006 and includes routine inspection of the completed Phase 1 ICM and the collection and analysis of surface water samples from the Phase 1 ICM area.

FMC and the Agencies discussed the scope of work for the second phase of the North Railroad Property ICM in 2005 through mid-2007. The Phase 2 ICM consists of construction of an engineered cover over the eastern portion of the former Northwest Conrail Area (see Section 4.7.5). In 2007, FMC submitted a document titled Phase 2 Interim Corrective Measures Work Plan for the North Railroad Property (ARCADIS BBL 2007b), which was substantially approved by the Agencies in June 2007. As described in Section 4.7.5, the Phase 2 ICM could not be performed during the 2007 construction season due to access and scheduling difficulties associated with power poles located within the Phase 2 ICM area. The Phase 2 ICM is scheduled for implementation during the 2008 construction season.

Volume IX of the RFI Report will present the results of the soil, surface water, and sediment investigations conducted at the FMC Plant Site, including the North Railroad Property.

3.2 Groundwater Investigations

3.2.1 Overview

FMC has investigated groundwater at and around the Facility since 1979, under various groundwater ICMs and studies including the comprehensive SI program (1985 to 1987), Surface Water Impoundment Monitoring Program (1985 to 1987), the Interim Groundwater Quality Assessment Monitoring Program (1988 to 1992), the Site Groundwater Quality Assessment Monitoring Plan (1989 to 1992), the GMP (1992 to present), the RFI (1993-1997), Private Water Well Study (2000 to 2002), Groundwater ICM Hydraulic Performance Monitoring (completed in 2000 to 2002), Supplemental Hydraulic Performance Assessment of Groundwater ICMs (2002 to 2004), Supplemental Downgradient Groundwater Investigation for ammonia in deep bedrock (2002 to 2006), VOC Groundwater Investigation (2006 to ongoing) and on-site and off-site vapor intrusion studies (2005 to ongoing). The results of these studies have been presented in a number of reports including the following:

- Middleport Site Investigation Final Report (CRA 1987).
- Description of Current Conditions Report (CRA 1991); Groundwater Assessment Report (CRA 1994c).
- 1999 Draft RFI Report (CRA 1999a).
- Groundwater Interim Corrective Measures Hydraulic Performance Monitoring Results (CRA 2002b).
- Private Well Study Summary Report (CRA 2002c).
- Supplemental Hydraulic Performance Assessment of Groundwater Interim Corrective Measures, (Geomatrix 2004a).
- Supplemental Groundwater Investigation Results (Geomatrix 2004b).
- VOC Groundwater Investigation Work Plan (Geomatrix 2006).
- Between 1979 and 1984, FMC developed and implemented several groundwater monitoring programs for the Site. These groundwater monitoring programs were determined at the time by the USEPA to be

consistent with the intent of the RCRA groundwater monitoring requirements in 40 CFR 265.

In 1985, FMC began implementation of the SI Program, which included a comprehensive hydrogeologic investigation and evaluation for the Facility. The SI was being performed under the New York State Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) program effective at that time pursuant to a work plan approved by the NYSDEC. The findings of the SI are presented in the Middleport Site Investigation Final Report (CRA, 1987). Findings relevant to the Facility groundwater characterization are summarized as follows:

- The overburden at the Site consists of fill material and native clayey till soils, and varies in thickness up to 14 feet. There is a downward vertical hydraulic gradient between the overburden and the underlying bedrock.

- The first bedrock unit encountered beneath the overburden is the upper limestone unit.

- Groundwater flow in the overburden and the bedrock units is north/northwesterly and is significantly influenced by the WSI underdrain system which removes groundwater from the overburden and shallow bedrock beneath the WSI.

- Overburden and shallow bedrock groundwater monitoring wells indicate that the primary groundwater constituents are arsenic, 7-hydroxybenzofuran, carbofuran, and methylene chloride. The highest concentrations of these compounds were primarily restricted to the northern half of the Site where manufacturing and waste disposal historically occurred.

In 1987, after discovering the presence of methylene chloride in the bedrock groundwater beneath the northeastern quadrant of the Facility, FMC developed and constructed a bedrock groundwater extraction well system for the Facility to minimize the potential for off-Site migration of methylene chloride in the groundwater beneath the Facility and to begin removal of methylene chloride. Operation of the four bedrock groundwater extraction wells installed at the Facility began in early 1988.

In 1985, the USEPA informed FMC that the WSI, CSI, and ESI were considered to be RCRA-regulated units for the purposes of permitting and groundwater monitoring. FMC submitted a RCRA Part B Permit Application (CRA, 1985) to the USEPA for the

Facility on November 8, 1985 and a Part 373 Permit Application (CRA, 1986a) to the NYSDEC in May 1986 to comply with applicable hazardous waste permitting rules and regulations at the time. FMC implemented the 1985-1987 groundwater programs to comply with the groundwater monitoring requirements (6 NYCRR Part 373-3 and 40 CFR Part 265, Subpart F) for the surface water impoundments. After 1987, FMC proposed and implemented Site-wide groundwater quality assessment monitoring programs (summarized in the table below) that evolved over years based on the findings obtained. Those groundwater programs included a groundwater monitoring program (GMP), as specified in the AOC.

Approximate Dates	**Groundwater Programs**
11/85 - 12/85	One well was installed upgradient and three wells were installed downgradient of each of the three surface impoundments.
12/85 - 5/86	The 12 monitoring wells were sampled for chemical analyses on four occasions as part of the Surface Water Impoundment Monitoring (SWIM) program to establish background conditions.
11/86 - 12/87	The first semi-annual monitoring event of the SWIM wells and several other confirmatory sampling events were implemented. Statistically significant changes from background conditions in water quality parameters were determined in some of the SWIM wells. FMC proposed to implement a Site-wide groundwater quality assessment monitoring program in place of the SWIM program.
1988 - 1989	FMC implemented an interim groundwater monitoring program until a final Site-wide groundwater quality assessment monitoring program could be developed and approved for the Facility. FMC also implemented a methylene chloride monitoring program as part of a methylene chloride groundwater control and removal program.
1989 - 1992	The Site Groundwater Quality Assessment Monitoring Plan (SGQAMP) (CRA 1988c) was approved by the NYSDEC. Implementation of the SGQAMP began in the fall of 1989 and included the installation of 19 additional monitoring wells. Groundwater quality monitoring wells were sampled quarterly for analyses of the SSPL. A total of 10 SGQAMP sampling rounds were conducted.
1992 - 1994	In order to satisfy the terms and conditions of the AOC, a GMP was developed to replace the SGQAMP and was implemented as described in the GMP Work Plan (CRA 1992 and CRA 1994a) after approval by the Agencies. Approximately 17 new monitoring wells were installed as part of the GMP. GMP monitoring wells (92 wells) were sampled annually for a comprehensive Groundwater Indicator Parameter List (GIPL) with a subset of 66 SSPL parameters and quarterly for a subset of the GIPL including 27 to 42 SSPL parameters.

Approximate Dates	Groundwater Programs
1995 - present	Based on the results of a 1994 Groundwater Assessment Report, FMC proposed modifications to the GMP which were subsequently approved by the Agencies. Several revisions of the GMP Work Plan for Remedial Systems Effectiveness Monitoring (CRA 1996c, 1998b, 2002a) have been prepared and implemented. Since 2002, the GMP has been modified, as appropriate based on the effectiveness monitoring results, and with approval of the Agencies.

From 1995 through 2005, over 110 new piezometers and monitoring wells have been installed for the purposes of the routine GMP groundwater quality and hydraulic assessments, and for RFI-related characterization of groundwater contamination. As of January 2006, over 240 monitoring wells, piezometers and extraction wells have been installed in and around the Facility, as shown on Figure I3.1 (includes unused and decommissioned/closed monitoring wells, piezometers and extraction wells). To date, approximately 75,570 chemical analyses have been conducted during repeated sampling of all or some of the monitoring wells, piezometers and extraction wells.

FMC's groundwater monitoring programs have included the routine sampling and analysis of over 70 monitoring wells and extraction wells at and around the Facility on a quarterly and/or semi-annual basis for parameters on the SSPL since 1989. The groundwater sampling results are evaluated and presented in the quarterly progress reports for the Facility pursuant to the terms and conditions of the AOC. As of January 2006, the GMP consists of the following:

- Semi-annual sampling of approximately 70 GMP monitoring wells (see Figure I3.2) for four indicators (total arsenic, methylene chloride, total ammonia, and ethylene thiourea or ETU). Biennial (every 2 years) sampling of approximately 70 monitoring wells for the GIPL (a subset of the SSPL).

- Quarterly sampling of all 14 groundwater extraction wells and the WSI underdrain at the Facility for the four indicators.

- Quarterly hydraulic monitoring program of over 190 piezometers/monitoring wells (see Figure I3.3).

- Quarterly and annual assessment of the performance of the groundwater ICMs.

- Annual evaluation of the groundwater quality, including the identification of any significant changes to the groundwater quality (i.e., the extent of contaminant presence) and hydraulics.

- Evaluation and recommendation of changes to the GMP.

- Reporting of the GMP results in the quarterly progress reports.

In addition to performance of the routine GMP, FMC has conducted or will conduct additional groundwater studies since the submittal of the 1999 Draft RFI Report to the Agencies. Those studies include:

- Groundwater ICM Hydraulic Performance Monitoring (completed in 2000-2002), which included the installation of 27 piezometers and one monitoring well.

- Private Water Well Study, including an inventory and sampling of private wells (completed in 2000-2002).

- Supplemental Hydraulic Performance Assessment of Groundwater ICMs (completed 2002-2004), which included evaluation of bacterial fouling of the trench extraction well systems and the hydraulic performance in the areas between Trenches B and C and east and north of Trench D.

- Supplemental Downgradient Groundwater Investigation (completed in 2002-2004) for further delineation of ammonia in the deep bedrock.

- Bedrock Groundwater Isotope Investigation (completed 2006-2007) to investigate the potential for ammonia to be present as a result of natural sources in the deep bedrock.

- Off-Site vapor intrusion studies (completed 2005-2007), which included the August 2005 sampling and analysis of soil gas from the Roy-Hart school yard; August 2005 installation of two new monitoring wells; fall 2005 groundwater sampling and analysis for VOCs of the new and existing monitoring wells; March 2006 sampling and analysis of ambient air, indoor air, crawl space air and sub-slab vapor at the Roy-Hart school buildings; April 2006 sampling and analysis of the Roy-Hart Acid Drain; implementation of the VOC Groundwater Investigation beginning in April 2006 (consisting of the

installation of six new monitoring wells the sampling and analysis of new and existing groundwater wells for VOCs); continued groundwater sampling and analysis for VOCs as part of the GMP; and February 2007 follow-up sampling and analysis of ambient air, indoor air, crawl space air and sub-slab vapor at the Roy-Hart Middleport school buildings.

- 2005 Groundwater ICMs and performance assessment (2005-2006), which included expansion of the groundwater trench extraction systems (see Section 4) and hydraulic monitoring and assessment of the new systems.

- On-Site soil vapor intrusion study (started in 2008), which consists of sampling and analysis of ambient air, indoor air, and sub-slab vapor at occupied buildings on the FMC Plant Site.

A detailed discussion of groundwater investigation results obtained to date will be included in Volume VIII of the RFI Report.

Both prior to and as a result of the extensive groundwater investigations, FMC has implemented a number of interim measures from 1987 through 2005 to remediate groundwater impacts at the Site and control off-Site migration of impacted groundwater. These interim measures include the WSI underdrain which has collected overburden and shallow bedrock groundwater from the northwest corner of the Facility since 1977; shallow subdrains (installed as part of the North Site Cover installation activities) which have collected overburden groundwater from along the northern perimeter of the Facility since 1988; bedrock groundwater extraction wells which have collected shallow and deep groundwater since 1987; and seven blast-fractured shallow bedrock groundwater migration control trenches (Trenches A, B, C, D, E, F, and G), 13 extraction wells associated with the trenches, and associated pumping systems which were installed from 1994 through 2005 to enhance the containment of off-Site groundwater migration and the collection of impacted groundwater from known source areas within the Facility. Section 4.0 further describes the groundwater interim measures performed at the Site.

3.2.2 Private Water Well Studies

FMC performed several private water well inventories and studies in 1985 through 1987, 1990, and 2000 through 2002. The most recent Private Water Well Study was performed in 2000 through 2002, as proposed in the 1999 Draft RFI Report. The purpose of the study was to update the water well inventory and to obtain additional

data for characterization of potential off-Site groundwater impacts from the Facility. In addition, data from this study has been used to evaluate the ammonia presence in the deep bedrock beneath and around the Site and potential ammonia impacts on surface water bodies downgradient of the Site. Completion of the 2000-2002 Private Water Well Study included the following tasks:

- Update of the existing Private Well Inventory; which included a survey of homes/property owners within a 1-mile radius of the Site.
- Selection of wells for sampling.
- Collection and analysis of samples from selected wells.
- Data evaluation and reporting.

The results of the 2000-2002 study are presented in the report Private Water Well Study Summary Report (CRA 2002c). The inventory listed 258 private wells around the Facility with 128 wells located within a 1-radius of the Site (CRA 2002c). Of the 128 private wells:

- 9 wells (well numbers 4, 7, 28, 50, 53, 54, 55, 56, and 177) were reportedly used for drinking water purposes.
- 20 wells were reportedly used or planned to be used for non-drinking water purposes.
- 97 wells were not accessible, filled in, buried, unused or were not known to exist by their owners.
- 2 wells were unknown usage.

Figure I3.4 identifies the private wells used for potable and non-potable purposes. Village of Middleport residents are required by ordinance to be connected to the Village of Middleport potable water supply system. The Village currently receives 100% of its water from the Niagara County Water District (since July 2001). Prior to July 2001, the Village supplemented 0 to 20% of its water supply from the Village well (private well number 1). The nine private wells used for drinking water purposes are located outside the Village limits. Five of the nine wells (numbers 4, 7, 54, 55, and 56) are hydraulically downgradient of the Site (CRA, 2002b).

A total of 48 private wells were sampled in 2000 as part of the 2000-2002 Private Water Well Study. Prior to that, FMC sampled some of the private wells in the mid 1980s and mid 1990s, and obtained available well data from the Niagara and Orleans county health departments. These data will be presented and discussed in Volume VIII of the RFI Report.

The Private Water Well Study Summary Report (CRA 2002c) concluded that private wells used for drinking water have not been impacted by Facility operations. The report also recommended further characterization of ammonia in deep bedrock and the installation and monitoring of sentry wells between the Facility and the private wells used for drinking usages. Both of these recommendations have been implemented as part of the Supplemental Downgradient Groundwater Investigation (2002-2004) and the ongoing GMP.

3.3 Off-Site Study Areas Investigations

The investigations of the off-Site areas, exclusive of the groundwater investigations, started in the mid 1980s. FMC continued to perform off-Site investigations from 1990 through the mid 1990s in accordance with the terms and conditions of a consent order (Index No. B9-0221-88-04, referred to herein as "OSI Order") executed by FMC and the NYSDEC (NYSDEC and FMC 1990). After the 1991 AOC was executed between FMC and the NYSDEC and USEPA, the Agencies requested that the off-Site investigations be performed as part of FMC's RCRA Corrective Action program, under the terms and conditions of the AOC. The investigations conducted through 2007 focused on the following off-Site study areas:

- Suspected Air Deposition Study Area South of the Erie Canal and West of the Niagara/Orleans County Line consisting of non-FMC owned residential, agricultural, public, commercial and industrial properties around the FMC Facility that may have been potentially impacted by historic air deposition from the Facility (including the Roy-Hart School Property, agricultural fields to the east and northeast of the Facility, the North Commercial/Industrial Area, and the 14 Western Residential Properties ICM Area).

- Culvert 105 storm sewer consisting of buried and open swale sections north and south of the Erie Barge Canal and potential flood zone areas traversed by Culvert 105.

- Tributary One South of Pearson Road and West of Stone Road and its floodplain (approximately from the Middleport Reservoir to Pearson/Stone Roads).

- Tributary One North of Pearson Road and East of Stone Road and its floodplain and contributing swales (approximately from Stone Road to its confluence with Jeddo Creek).

- Jeddo Creek and its floodplain and contributing swales (approximately from its confluence with Tributary One to its confluence with Johnson Creek).

- Johnson Creek and its floodplain and contributing swales (approximately from its confluence with Jeddo Creek to Johnson Creek Pond in Lyndonville).

The following list describes the primary studies/events associated with the off-Site studies in chronological order:

- November 1985 – FMC collected eight soil samples at the schoolyard in Middleport and two background samples from the Gasport Elementary School at the request of the Roy-Hart School Board, with oversight from the NYSDEC. The soil samples were analyzed for arsenic, lead, mercury, total phenols, total chlorinated hydrocarbons, carbofuran, DDD, dichlorodiphenyldichloroethylene (DDE), and DDT. Some of the soil samples were split with the NYSDEC and were analyzed for other constituents by the NYSDEC.

- November 1986 – The NYSDEC collected additional soil/sediment samples from the Roy-Hart schoolyard, Tributary One of Jeddo Creek, and Culvert 105 swale. Based upon the analytical results obtained, the NYSDOH recommended that public access to the area on the school property south of the bleachers be restricted and that further investigation of the schoolyard be conducted.

- March and December 1987 – As a result of the NYSDOH recommendation, FMC collected more than 80 additional soil samples from the area of the Roy-Hart schoolyard in March and December of 1987, for a total of over 200 chemical analyses. The Roy-Hart School Board restricted access to the Northern Ditches by erecting a temporary fence.

- Late 1987 through mid 1988 – under an Order on Consent (File No. 87-49) with the NYSDEC (NYSDEC and FMC 1987), FMC excavated the top 8 inches (approximate) of impacted sediments from and restored the Northern Ditches in 1987 and 1988 to address the recommendation of NYSDOH to limit public exposure to sediment/soil in the Northern Ditches. Soil samples were collected from the bottom of the excavated Northern Ditches prior to placing a minimum 8-inch thick clay and stone cover as part of the 1987 and 1988 restoration activities. The analytical results for these samples are presented in the Northern Ditches Restoration Construction Report (CRA 1988b).

- 1987 - 1989 – The NYSDEC requested that FMC conduct an extensive investigation of off-Site areas which could have been potentially affected by historical Facility operations. FMC and the Agencies discussed and agreed to the scope of work for the OSI. FMC subsequently prepared an OSI Work Plan (CRA 1989a) and the NYSDEC approved the OSI Work Plan in early 1990. As previously discussed, the Master Compound List Document (see Appendix 2A) was developed and included the SSPL (see Table 2.7). The SSPL was intended for use in subsequent environmental investigation programs, including the OSI.

- 1990 - 1993 – FMC began implementation of the OSI Work Plan in August 1990 in accordance with the terms and conditions of a consent order (Index No. B9-0221-88-04) executed by FMC and the NYSDEC (NYSDEC and FMC 1990). Over 13,000 chemical analyses (for the SSPL parameters) were conducted on over 400 soil, surface water, and sediment samples collected from off-Site study areas which included Tributary One, private properties around the Facility, the Northern Ditches, the Northwest Conrail Property, the Roy-Hart School bleacher area property, the floodplain of Tributary One (south of the Erie Canal and north of Francis Street), Jeddo Creek, and the Erie Canal. An OSI report was submitted to the Agencies in July 1991, and FMC subsequently performed additional sampling and analyses and assessment, in accordance with NYSDEC's request (NYSDEC 1992) and revised the OSI Report (CRA 1993c). That revised report was submitted to the Agencies in August 1993 and included a health and environmental risk assessment in accordance with the provisions of the OSI Order. The environmental risk assessment included a fish and wildlife impact analysis performed in accordance with NYSDEC-approved work plans, NYSDEC draft guidance titled Fish and Wildlife Impact Analysis for Inactive Hazardous

Waste Sites (NYSDEC 1991), and USEPA guidance titled Risk Assessment Guidance for Superfund, Volume II: Environmental Evaluation Manual (USEPA 1989). As part of the OSI, habitat and stream surveys were performed in the vicinity of Middleport to identify various habitats and potential ecological receptors near the Facility and various off-Site areas (ICF, 1993). In addition, toxicity testing was performed on sediment samples collected from Tributary One. The results of the ecological surveys and the sediment toxicity study are presented in Appendix 5B of the 1993 OSI Report (CRA 1993c). The August 1993 OSI Report concluded that the OSI study areas did not present any significant threats to human health and the environment and therefore a feasibility study was not needed. Further action was recommended for the Northwest Conrail Property to address the presence of visible impacts in the shallow subsurface soils. The NYSDEC has not provided comments on or approved the August 1993 OSI Report.

- July 1991 – FMC, NYSDEC, and USEPA enter into the AOC.

- 1991 - 1993 – FMC and the Agencies finalize the scope of work for the first phase of the RFI field investigations. FMC submitted two versions of the RFI Work Plan; the July 1993 version of the work plan was approved by the Agencies and included soil sampling at the FMC Plant Site and FMC's Former R&D Property and additional groundwater investigations.

- March 1995 – FMC submitted a Draft Focused Feasibility Study Report (CRA 1995) to assess the presence of Site-related chemicals in the off-Site study areas and evaluate several remedial alternatives. The NYSDEC has not approved this draft report.

- 1995 – The Agencies requested additional soil sampling at off-Site areas as part of FMC's RFI, in comments and directives related to the RFI Field Investigation Summary Report (Agencies 1995a). FMC conducted Phase II RFI soil sampling activities in September and December of 1995. The Agencies did not grant approval of the September and December 1995 Phase II RFI soil sampling activities.

- July/August 1996 – Pursuant to an administrative consent order by the NYSDEC, FMC implemented an IRM to remove 2 feet of soil from behind the Roy-Hart School bleachers to address the Agencies' concerns with the arsenic presence in these soils. Soil samples were collected from the

remaining soil in the base of the excavation behind the bleachers prior to backfilling with approximately 2 feet of cover material.

- July 1996 - April 1997 – FMC and/or the Agencies collected additional soil samples from off-Site properties adjacent to the FMC Facility, including residential properties north and northwest of the Site, the Roy-Hart school bleachers and the football field area in July 1996, November 1996, and April 1997 sampling events. These results, and the data collected as part of the OSI, were incorporated into the RFI. After review of the soil sample data collected through April 1997, the Agencies notified FMC by letter dated July 16, 1997 that the "Agencies consider soil sample database to be sufficient for FMC to prepare and submit the Draft RFI Report" (Agencies 1997b).

- 1997 - 1999 – A draft RFI Report was submitted to the Agencies in November 1997 and a revised draft RFI Report, responding to comments provided by the Agencies, was submitted on January 29, 1999. The revised draft RFI Report includes a summary of the various investigative and monitoring data collected through the first six months of 1998.

- 1998 – The USEPA completed a baseline human health risk assessment of the Roy-Hart School Property in Middleport and the Agencies determined that an ICM was necessary for removal of arsenic containing soil from the school football field/track area.

- 1999 - spring 2000 – FMC completed ICM construction activities at the southwest quadrant of the Roy-Hart School Property (CRA 2000b), which includes the football field, track, bleachers, and school bus garage parking area. The ICM included excavation of soil from within the ICM area; placement of the excavated soil in the ESI at the Facility; backfilling the excavated areas with clean soil and restoration of the disturbed areas of the Roy-Hart School Property. FMC also constructed new athletic facilities (i.e., all-weather track, football field, field house, bleachers, etc) at the High School.

- 2000 - 2002 – The Agencies proposed a program for the re-evaluation of local arsenic background levels in soils in the Middleport area in 2000. Following discussions on the scope of work, the Agencies issued a final approved work plan – Part A – Work Plan for Development of Arsenic Background in Middleport Soil – in November 2001 and FMC implemented

the plan beginning in December 2001. Completed activities included the collection and analysis of over 100 soil samples from orchards, agricultural fields, wooded areas, commercial/industrial properties, and residential areas in Gasport. FMC issued a final report in February 2003, with revisions submitted in May 2003. The Agencies approved the report in June 2003.

- 2001 - 2002 – FMC and the Agencies discussed remaining data gaps in the RFI and the scope of work for additional sampling and analysis in certain off-Site study areas, including consideration of the program to re-evaluate soil arsenic background levels for the Middleport area. FMC submitted a 2002 Sampling Program Work Plan (CRA 2002d) in August 2002 for further soil sampling analysis in the North Commercial/Industrial Area, the 14 Western Residential Properties ICM Area, FMC's Former R&D Property, the North Railroad Property (i.e., the Northern Ditches); Culvert 105 and areas along Culvert 105; and Tributary One South of Pearson/Stone Roads and its floodplain. The Agencies approved the work plan and FMC performed the work beginning in September 2002. The results were presented in the Draft 2002 Sampling Program Report, which was submitted to the Agencies in June 2003 (CRA 2003b).

- 2003 – FMC performed an ICM to remove FMC's former outfall sewer (which conveyed wastewater and stormwater discharges from the Facility to Tributary One prior to 1977 and which also was part of the Village of Middleport storm sewer system) and soils from the 14 Western Residential Properties ICM Area. The ICM included replacement of the storm sewer, backfilling of excavated areas with clean soil and restoration of the ICM area in 2003. A draft construction report was submitted to the Agencies in November 2004, and was approved by the Agencies in March 2007.

- 2003 - 2004 – The Agencies requested additional sampling and analysis of the North Railroad Property, Tributary One, Culvert 105, and the Historic Air Deposition Off-Site study areas. FMC and the Agencies discussed and finalized the scopes of work for the study areas. FMC implemented the approved work scopes for the North Railroad Property, Tributary One, and Culvert 105 study areas in early 2004. FMC performed sampling and analysis of the Historic Air Deposition Off-Site study area in the fall of 2004. The Agencies requested and FMC performed a second phase of sampling and analysis of the Tributary One and Culvert 105 study areas in the fall of 2004.

- 2005 – FMC completed the studies for the North Railroad Property and implemented a Phase 1 ICM in the summer of 2005.

- 2005 - 2007 – The Agencies requested that FMC evaluate potential vapor intrusion at the Plant Site and in off-Site study areas (i.e., Roy-Hart School Property) as part of the NYSDEC's state-wide initiative to evaluate potential vapor intrusion at all sites in New York State where chlorinated VOCs have been detected in soil and/or groundwater. FMC began implementation of the off-site studies in August 2005, pursuant to an approved Off-Site Soil Gas Investigation Work Plan (BBL 2005e) and completed the initial phase in the fall of 2005 (as discussed in Section 3.3.1). In January 2006, the Agencies determined that additional off-site vapor intrusion studies, (including the collection of indoor air, crawl space air and sub-slab vapor samples from the Roy-Hart Middleport school buildings and additional groundwater investigations for VOCs) were necessary. The additional air/vapor sampling and analysis were performed as specified in the approved Addendum No. 1 to the Off-Site Soil-Gas Investigation Work Plan (BBL 2006a) in March and April 2006. Additional groundwater investigations were also completed in April 2006 through the summer of 2006 as specified in the approved VOC Groundwater Investigation Work Plan (Geomatrix 2006).

- September 2005 - 2006 – The Agencies approved FMC's draft outline for a Revised RFI Report and directed FMC to begin preparation of the Revised RFI Report in September 2005. In September 2005, the Agencies requested additional sampling and analysis in the Tributary One South of Pearson/Stone Roads, Culvert 105, and the Historic Air Deposition Off-Site study areas. FMC and the Agencies discussed and finalized the scopes of work for the study areas. FMC implemented the approved work scopes in November and December 2005. Validation of the sample data was completed and the Agencies approved the data quality in mid-2006.

- 2006 – In January 2006, FMC submitted a work plan for sampling and analysis of sediment and soil in and along Tributary One north of Pearson Road; portions of Jeddo Creek and Johnson Creek; and some feeder tributaries along these water courses. In March 2006 the Agencies (in consultation with the NYSDOH) provided their conditional approval, and FMC submitted a revised Work Plan in response to the conditional approval. FMC conducted field investigations and sampling activities (with Agencies oversight) in April and May 2006. Validation of the data was completed and

the Agencies approved the data quality (including their split samples) in January 2007.

- September 2007 - ongoing – The Agencies and FMC agree that separate RFIs and CMSs should be completed (similar to an "operable unit" concept) for each of the following three study areas: 1) Culvert 105 and the flood zone; 2) Tributary One & floodplain south of Pearson Road; and 3) Suspected Air Deposition Study Area south of the Erie Canal and west of the Niagara/Orleans County Line (which includes the North Commercial/Industrial Area and the Royalton Hartland School Property). In addition, the Agencies also determined that additional soil sampling was needed in the following areas: 1) Along and north of the Barge Canal property between the end of Williams Street and Grid Point SS33 in previous Sampling Area R1d; and 2) East of the Niagara/Orleans County Line between Grid Point WW36 in previous Sampling Area R1a and Grid Point D36 in previous Sampling Area R1b.

The results of the off-Site studies performed from the mid 1980s through mid-1998 are summarized in the 1999 Draft RFI Report. Those studies included the analysis of environmental samples for FMC's SSPL, which was developed based on a detailed evaluation of all materials historically handled at the Plant Site. Based on the results of the studies performed through mid-1998, the 1999 Draft RFI report concluded that arsenic is the predominant Site-related chemical present in off-Site study areas and was most frequently detected at elevated concentrations.

After submittal of the 1999 Draft RFI Report, the Agencies determined that additional studies were warranted in the off-Site study areas to further delineate the extent of FMC-related arsenic presence in soil and sediment. This determination was based in part on the re-evaluation of arsenic soil background levels in 2001-2003. Additional sampling and analyses were performed in several phases as part of the RFI from 1999 through 2007 under the terms and conditions of the AOC.

3.4 Agencies' Public Health Studies Risk Assessments

3.4.1 1986-1987 NYSDOH Public Health Investigations

In 1986 and 1987, the NYSDOH conducted two public health investigations to assess potential public health impacts:

1) A cancer incidence investigation for the Village of Middleport.

2) A biological monitoring program for students and maintenance workers at the Roy-Hart Elementary and High Schools located north and northeast of the Facility.

The cancer incidence investigation was initiated in October 1986 by NYSDOH Bureau of Cancer Epidemiology. Cancer incidence data from 1976 through 1984 for the Village of Middleport was obtained from the New York State Cancer Registry. Age- and sex-specific incidence rates for areas of similar population density for 1978-1982 were used to estimate the expected number of cases among the residents of the study area. Comparisons between the observed and expected number of cases were made for all cancer sites combined and for 17-19 specific anatomic cancer sites for men and women. NYSDOH concluded that the observed number of cancer cases in the Village of Middleport for adults (both men and women) and children were similar to the expected number for all comparisons (i.e., the small deviations between the numbers of observed and expected cases were within the range that occurs by chance when comparing a single community with a large population). The findings of the study were published in a report issued by NYSDOH (Bureau of Cancer Epidemiology) in April 1987 and titled Incidence of Cancer in the Village of Middleport (Niagara County), New York (NYSDOH 1987a).

To determine whether students and maintenance workers at the Roy-Hart Middleport schools might be experiencing an increased uptake of arsenic and lead from schoolyard soils, the NYSDOH conducted a biological monitoring program for students and workers on a voluntary basis in May and June 1987. The program measured arsenic and lead concentrations in urine, blood, and/or hair samples in Middleport student and worker populations with the greatest potential for exposure to schoolyard soils: kindergarten and first grade students and high school athletic team members, and maintenance workers who worked in the area of the maintenance garage and on the school grounds. Participation rates were well above 50% for the urinary arsenic and blood lead analyses. The biological monitoring program was also implemented at a control school within the East Greenbush School District, located in the Albany area. The results of the biological monitoring program were published in reports issued by the NYSDOH in 1987 and titled Biological Monitoring of School Children in Middleport, New York for Arsenic and Lead (NYSDOH 1987b) and Results of Biological Monitoring Program for Arsenic and Lead: Middleport

Elementary and Roy-Hart Junior/Senior High Schools (NYSDOH 1987c). The conclusions of the reports are quoted below:

> *In conclusion, when the results of hair arsenic, blood lead and blood EP levels in Middleport students were compared to students from a control school they were found to be similar. Although a statistically significant difference in urinary arsenic levels was not detected, it is possible that there was increased low level absorption of arsenic by the Middleport children. There is a potential for increased individual exposure to arsenic and lead in the soil in the school yard. Normal use of the school yard is not likely to result in measurable uptake of arsenic or lead in the body compared to the normal daily intake from all sources (i.e., diet), but such contact may result in increased exposure and some associated increase in risk, however small.*

3.4.2 1998 Roy-Hart School Public Health Risk Assessment

In 1997, the USEPA contracted TechLaw, Inc. (TechLaw) to perform a baseline human health risk assessment of the arsenic concentrations in the school yard soils using the soil sampling database developed through 1998. The results of the risk assessment were documented in a report titled Royalton-Hartland Schoolyard Draft Baseline Human Health Risk Assessment (TechLaw 1998) that was provided to FMC by letter dated August 11, 1998 (see Appendix 3B). The risk assessment evaluated the potential health risks from a site-wide (i.e., entire school yard) and area-specific exposure scenarios (i.e., track/football field area, baseball/soccer field areas, etc.) to arsenic in soil. The risk assessment utilized exposure assumptions that were intended to reflect actual day-to-day use of the school yard by students and student athletes. At the time the risk assessment was performed, the school buildings were utilized by students in grades kindergarten through 12.

The results of the risk assessment indicated that the arsenic levels (based on data gathered prior to 1999) in the surface soils within the track and football field area posed potential health risks that exceeded the USEPA's Health Hazard Index of 1.0 for toxic risk and the USEPA's 10^{-4} to 10^{-6} acceptable cancer risk range. Accordingly, by letter dated August 11, 1998, the Agencies requested that FMC perform an ICM. The ICM Area (see Section 4.10), which consisted of the southwestern portion of the school property (including the track and football field area and the school bus garage area) was selected by the Agencies based on the results of the baseline human health risk assessment. FMC agreed to conduct the ICM and submitted a proposed work plan for the ICM. The Agencies conducted a public meeting on October 27, 1998 concerning the proposed ICM and solicited public comments on the proposed

ICM and the risk assessment results from October 27 through December 11, 1998. The Agencies summarized and responded to the public comments in a Responsiveness Summary for the Royalton-Hartland School Yard Interim Corrective Measure, dated April 1999 (see Appendix 3B). As part of their response to comments, the Agencies re-evaluated the arsenic levels (data gathered prior to 1999) in the school yard outside of the ICM Area and the associated potential human health risks for three post-ICM exposure scenarios. The three exposure areas evaluated included: 1) the entire school yard, 2) the area behind the High School, and 3) behind the former elementary school (currently the Middle School). In addition, the Agencies also determined the potential carcinogenic risks to students calculated from the local background arsenic data (as presented in the 1999 Draft RFI Report and summarized in Section 6.1) and compared those risks to those calculated for each of the school yard exposure scenarios. Based on that review and comparison, the Agencies stated in the responsiveness summary (in the Agencies' Response to Comment Topic 1) that:

"…the Agencies consider the "post-ICM" average arsenic levels in the school yard soils to be consistent with the arsenic levels of the local background data set…"[4] and

"…the Agencies consider the "post-ICM" potential non-cancer health risk to students to be below the EPA threshold limit, and the "post-ICM" potential carcinogenic risk to students to be within EPA's range of acceptable carcinogenic risks and similar to the potential carcinogenic risk associated with the local background soil arsenic data set."

FMC performed the ICM beginning in 1999 (see Section 4.10), removed (excavated) approximately 39,000 cubic yards of soil, backfilled the excavated areas with clean soil, and restored the school yard and athletic facilities. After completion of the ICM, by letter dated May 26, 2000, the Agencies informed the Roy-Hart School District that "the Agencies have determined that the entire school yard is suitable for both athletic and non-athletic uses by all school children, in terms of their exposure to known school yard soil arsenic levels."

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[4] The "local background data set" refers to the eleven (11) background sample results available at the time of the school yard ICM (1999). The Agencies stated in the 1999 responsiveness summary (in Response to Comment Topic 9) that they were "re-evaluating the local arsenic background for Middleport soils."

3.5 2004 Biomonitoring Study

At the request of the Middleport Community Advisory Panel, FMC funded a study of the Middleport community to evaluate potential exposure of residents to arsenic from soil in the Middleport area. This study began in 2003 and included biomonitoring of residents for arsenic exposure; sampling for arsenic in soil, house dust and garden produce; and collection of survey responses on potential arsenic sources and factors affecting exposure. The study was conducted by an independent contractor, Exponent, with outside review by an independent Science Advisory Panel (SAP), which included scientists from several universities, health institutes, and the Centers for Disease Control and Prevention (CDC) with expertise in biomonitoring and environmental exposure assessment.

This voluntary biomonitoring study:

1) Examined urinary arsenic levels in young children less than age 7 (the target population of most concern for soil exposure) and older individuals (at their request) within and just beyond the Village of Middleport (bounded by Carmen Road, Pearson Road, Mountain Road and the Niagara-Orleans County Line).

2) Examined the correlation between biomarkers of arsenic exposure (e.g., urinary arsenic levels) and arsenic in soil and in house dust.

3) Assessed indirect indicators of arsenic exposure based on questionnaire responses.

4) Provided study participants with individual biomarker and environmental arsenic levels and the Middleport community with group-level information of biomarker levels.

The biomonitoring study area (bounded by Carmen Road to the west, Mountain Road to the south, the Niagara/Orleans county line to the east, and Pearson Road to the north) included FMC's RFI sampling areas and areas outside of the sampling areas. The study area was designed to provide maximum opportunity for detection of any increased arsenic exposures by including residents whose properties had a wide range of soil arsenic concentrations. The ability to detect elevated exposures is dependent on being able to compare exposures among residents with a range of potential exposures. While participation was voluntary, the goal of including properties with a range of soil arsenic concentrations was accomplished, with some

concentrations both above and below the background concentrations identified in the 2001-2003 Gasport Soil Background Study (CRA 2003). Summary statistics of arsenic concentration in soil samples collected in yard, garden, and play areas (up to 6 inches in depth) at 85 properties of participants in the biomonitoring study are provided in Table 3.2 of this Volume I (which is a replication of Table 9 of the report titled Middleport Environmental Exposure Investigation [Exponent 2004a]).

The total population size within the study area was estimated to be 1,930. A total of 439 Middleport residents (including 77 children aged 6 years old and younger) voluntarily participated in the biomonitoring study. Urine and toenail samples were collected from the participants during the summer months of 2003 (when exposure to soil would theoretically be highest). Soil, house dust, and homegrown produce samples were collected from study participants' residences where the property owners granted FMC permission to collect the samples. The soil, house dust, and homegrown produce samples were analyzed for total arsenic. Toenails and urine samples were analyzed for total arsenic. The urine samples were also analyzed for speciated arsenic (e.g., inorganic and organic arsenic).

The results of the study were presented in the report titled Middleport Environmental Exposure Investigation (Exponent 2004a) and were provided to the Agencies. Appendix 3C includes a copy of the 2004 report. Urine results from all study participants were within expected levels from diet and other background sources. The speciated arsenic levels were compared to arsenic levels in soil, house dust, and homegrown produce. Careful attention was given to other exposure factors (i.e., diet), individual activities (i.e., playing in the creek) and other potential sources of arsenic. The report concluded that:

1) Arsenic levels in urine and toenail samples were low and below the study's reference levels.

2) There is no clear evidence that exposure to arsenic in soil or house dust increased speciated arsenic in urine of children less than 7 years old or of older participants.

3) Eating garden vegetables, playing in creeks or other soil-related behaviors were not associated with increased urinary arsenic levels.

4) Sources of inorganic arsenic other than soil (likely background levels in water and diet) are the primary contributors to inorganic arsenic exposure in the Middleport community.

The 2004 Biomonitoring Study was not required by the RFI and was not approved or disapproved by the Agencies. FMC voluntarily funded the study at the request of the Middleport Community Advisory Panel. The Agencies have not indicated agreement or disagreement with the report's conclusions; however, prior to completion of the study and issuance of the report documenting the results, the Agencies did express reservations about how the results of such a study would be used.

3.6 Soil Arsenic Bioavailability

3.6.1 Oral Arsenic Bioavailability

As part of the 1990-1993 OSI, human health risk assessments were performed for the areas investigated. The results of the risk assessments are documented in the 1993 OSI Report (CRA 1993c). The human health risk assessments used a bioavailability adjustment factor of 0.33 for ingestion of arsenic from soil based on scientific judgment and available toxicological literature. The Agencies did not approve the risk assessments.

In 1995, FMC contracted PTI Environmental Services (PTI) to conduct further evaluations of oral arsenic bioavailability and to perform Site-specific studies to determine an appropriate arsenic bioavailability adjustment factor for soils adjacent to the Facility. This 1995 study involved:

- An evaluation of arsenic bioavailability studies conducted to date, including animal studies and *in vitro* laboratory studies.

- Identification of experimentally determined bioavailability factors for arsenic in soil and precedents for the use of soil arsenic bioavailability factors used in risk assessments for other arsenic contaminated sites.

- The performance of *in vitro* lab testing and arsenic mineralogy studies on 12 soil samples collected from residential properties located adjacent to the northwest corner of the Facility and from behind the bleachers at the Roy-Hart high school track.

- The 1995 study determined a Site-specific oral arsenic bioavailability factor of 0.20 for Middleport soils. The results of the 1995 study are summarized in the report titled Estimation of Arsenic Bioavailability from Soil, FMC Middleport Plant Site, New York (PTI 1995).

While FMC believes that the 1995 mineralogy and *in vitro* data are adequate to support bioavailability adjustment for use in a site-specific risk assessment, the Agencies advised that the 1995 findings would be strengthened if confirmed by an animal study. Consequently, FMC contracted with Exponent to perform another arsenic bioavailability study that included both laboratory (*in vitro)* and animal (*in vivo*) testing to supplement the findings of the previous studies and to provide an estimate of the relative oral arsenic bioavailability in Middleport soils (Exponent 2004a). In June 2003, FMC submitted a draft work plan for the evaluation of arsenic bioavailability from Middleport soil to the Agencies. Based on comments from the Agencies, FMC submitted a revised work plan in February 2004 (Exponent 2004b). By letter dated July 30, 2004, the Agencies provided comments on the revised work plan and stated that "FMC should consider the Agencies' enclosed recommendations, and proceed with the study." Exponent proceeded to implement the study in late 2004 and completed it in 2006.

The activities related to the 2004-2006 oral bioavailability evaluation of arsenic in Middleport soils consisted of:

- The collection of 13 surface soil samples (0- to 3-inch depth) and 4 subsurface soil samples (6- to 12-inch depth) from Middleport study areas (i.e., residential properties from the 14 Western Residential Properties ICM Area and residential and wooded properties from the floodplain of Tributary One South of Pearson/Stone Roads);

- Evaluation of arsenic mineralogy and *in vitro* testing of the 17 samples for the measurement of arsenic bioaccessibility (i.e., the fraction that could become solubilized in the gastrointestinal tract and be available for absorption);

- Selection of three of the 17 soil samples collected from Middleport for *in vivo* testing for arsenic bioavailability;

- Performance of *in vivo* testing of the three selected Middleport soil samples in cynomolgus monkeys as part of a larger research study being performed

at the University of Florida to determine the relative oral bioavailability in the cynomolgus monkeys; and

- Preparation of a report that presents the study results and conclusions and that identifies a Site-specific oral bioavailability factor for arsenic in Middleport soil supported by the studies performed to date.

Exponent prepared a Technical Memorandum, dated June 2005, that presents the preliminary results of the arsenic mineralogy characterization and *in vitro* testing of the 17 soil samples collected from Middleport (Exponent 2005). The memorandum also identified the three soil samples selected for *in vivo* testing. FMC submitted a copy of the memorandum to the Agencies by cover letter dated June 27, 2005. Based on the arsenic mineralogy and *in vitro* evaluations, three soil samples were selected for the *in vivo* testing using monkeys. The *in vivo* testing of the monkeys was completed in late 2005-2006. The results of the site-specific oral bioavailability factor study were reported as part of a larger study conducted at the University of Florida in a report issued in early 2007. A summary of the results for the Middleport soil samples was presented in a Technical Memorandum prepared by Exponent and submitted to the Agencies in September 2007 (see Appendix 3D). The relative oral bioavailability of arsenic in these three soil samples from Middleport was 19%, 20% and 28% when tested in the monkeys. This means that if Middleport soil containing arsenic is ingested, the fraction of the arsenic absorbed would be only one third to one fifth of the fraction that would be absorbed if water had been ingested containing the same amount of arsenic dissolved in the water. This result is consistent with the results from testing soil from 11 different sites throughout the United States, which yielded relative bioavailability estimates ranging from 5% to 31% (Roberts *et al.* 2007, see Appendix 3D). It is also consistent with the results of the prior *in vitro* testing conducted in 1995 and 2004.

The 2004-2006 oral bioavailability evaluation of arsenic in Middleport soils was not required by the RFI and although the Agencies commented on the work plan, they did not approve or disapprove this evaluation. The Agencies have not indicated agreement or disagreement with these results or the above interpretation; however, they have expressed some concerns related to uncertainty factors which can influence any bioavailability estimate.

3.6.2 Dermal Arsenic Bioavailability

In January 2004, FMC informed the Agencies of its intention to perform an animal study (using a Rhesus monkey model) of dermal absorption of arsenic from soils found in the Middleport Study area. By letter dated January 20, 2004, FMC provided a copy of the study protocol to the Agencies. The University of California at San Francisco began the study in 2004 in concert with other dermal arsenic absorption studies for the Department of Defense (DoD). A soil sample collected from one of the residential properties within the 14 Western Residential Properties ICM Area (collected prior to removal of soil from the ICM area) was included as one of two soil samples evaluated for dermal absorption of arsenic in the Rhesus monkey model.

The results of the dermal arsenic absorption study for the Middleport soil samples was reported as part of a larger study conducted at the University of California at San Francisco that was included in a report published in September 2007. A summary of the results for the Middleport soil samples was presented in a Technical Memorandum prepared by Exponent and submitted to the Agencies in September 2007 (see Appendix 3D). Middleport soil was tested in the monkey study to determine if any of the arsenic could cross the skin and be absorbed dermally. This study demonstrated that virtually no arsenic is absorbed across the skin even when soil is spread on the skin and held in place with a kind of bandage.

The 2004-2007 dermal arsenic absorption study of arsenic in Middleport soils was not required by the RFI and was not approved or disapproved by the Agencies. The Agencies have not indicated agreement or disagreement with its conclusions.

4. Previous and Ongoing Remedial Activities

Over the past 30 plus years, FMC has implemented a variety of operational and interim measures to mitigate potential environmental concerns identified during numerous investigations dating back to 1973. These remedial activities have had a positive impact on the environment and the ultimate remediation of the Facility. Many of these activities have limited potential human exposures to Site-related chemicals in on- and off-Site soil, sediment, surface water, and groundwater.

Table 4.1 lists all of the operational and corrective measures implemented at the Facility through 2007 along with the media addressed, the purpose for the measure, and the resulting benefit to the environment and/or human health. The subsections below describe the major remedial measures performed at the Facility.

4.1 Water Treatment Plant

In 1977, a WTP and a 1.5 million gallon, lined surface water impoundment (referred to as the WSI) with a groundwater collection underdrain system (WSI Underdrain System) was constructed at the Facility to collect and treat the impacted surface water runoff from the northern half of the Facility. Two additional impoundments, the CSI and ESI, were constructed in 1978 to provide additional stormwater retention capacity during periods of peak runoff. From 1977 to 1988, surface water from the northern half of the Facility was collected and stored in the three impoundments prior to treatment in the WTP. Following cleanout and installation of a new liner in the WSI in 1988, surface water and/or groundwater has been collected and stored in the re-lined WSI and in two 600,000-gallon storage tanks (T-1101 and T-1102) prior to treatment in the WTP and discharge under the terms of the Facility's SPDES permit.

The WTP currently treats surface water from the northern half of the Facility and groundwater extracted or otherwise collected from the groundwater remedial systems described in Section 4.8, below, prior to discharge to Tributary One and in accordance with the terms and conditions of the Facility's SPDES permit (NY No. 0000345). The various unit processes in the WTP are as follows:

Process	Purpose
Equalization	Equalization of influent flow and water quality
Multi-media filtration	Solids removal
Carbon adsorption and filtration	Removal of organic compounds
Ion exchange	Ammonia removal
Chemical precipitation with sludge dewatering	Removal of arsenic, zinc, and any other heavy metals

Figure I4.1 illustrates the general treatment process for the WTP (as of the end of 2007). Treated water is temporarily stored in a treated water holding tank, sampled for analysis, and discharged to Tributary One in accordance with the terms and conditions of the Facility's SPDES permit.

Since 1977, a number of upgrades to the WTP were performed including the replacement of the clarifier and sludge dewatering system. In 2006-2008, FMC performed a major upgrade and rehabilitation of the WTP to optimize operations and removal efficiencies and to modernize the existing equipment and controls. The NYSDEC approved this upgrade and rehabilitation program in August 2006. FMC began implementation of the upgrade project in late 2006 and substantially completed the project in the first quarter of 2008. As requested by the NYSDEC, the upgrades have been implemented in a manner that minimized the downtime of the WTP and any potential for SPDES permit violations, to the extent practicable.

The WSI was constructed in 1977 as a storage and equalization basin for the WTP and has a maximum capacity of 1.5-million gallons. The WSI was excavated below grade into the bedrock and was lined with a chlorosulphonated polyethylene (hypalon) liner. An underdrain system, consisting of a series of 6-inch-diameter perforated polyvinyl chloride (PVC) piping, was installed beneath the liner to minimize the potential for hydrostatic uplift and stress with respect to the liner. The underdrain system was built on bedrock and extends approximately 3 feet into the bedrock underlying the impoundment. The underdrain system and associated collection sump pump extract groundwater from the overburden and shallow bedrock from beneath the WSI and the immediate areas to the north and west of the Site. The extracted groundwater has been directed to the WTP for treatment and discharged in accordance with the Facility's SPDES Permit. As a result, the operation of the WSI underdrain system reduced migration of impacted groundwater and created a

hydraulic depression in the overburden and shallow bedrock in the vicinity of the WSI since 1977.

4.2 North Site Cover and Pre-Closure Activities

In 1987 and 1988, FMC implemented a project to cover, decontaminate, and/or contain all potentially impacted surface areas on the northern portion of the Facility. The proposed program was presented in a report titled Pre-Closure Activity Plan (CRA 1986b), submitted to the NYSDEC on September 2, 1986. As part of this program, FMC diverted the discharge from a series of existing shallow subdrains and constructed new subdrains to intercept shallow groundwater, which otherwise could have been discharged to the surface water system. This intercepted groundwater was pumped to tanks T-1101 and T-1102 and directed to the WTP for treatment prior to discharge under the SPDES permit. This program was designed to:

- Prevent or minimize the off-Site migration of surficial constituents from the Facility via the surface water and air pathways.

- Prevent or reduce the level of Site-related constituents that may be present in the surface water runoff from the northern half of the Facility so that the surface water impoundments could be removed from service and/or closed in accordance with applicable regulations.

- Enable the surface water runoff from the covered northern portion of the Site to meet the SPDES permit limits without treatment.

Work associated with this program extended over a 2-year period and was substantially completed in the fall of 1988. The components of the pre-closure activity program constructed and/or implemented at the Facility are as follows:

- Revised Site grading and surface water drainage plan designed to ensure all areas on the northern half of the Facility are adequately drained.

- Low-permeability surficial cover (North Site Cover) over permeable surfaces on the northern portion of the Facility which consists of either a composite clay/sand/topsoil cover (2 feet minimum thickness) or asphaltic concrete surfacing (3 to 5 inches in thickness).

- Modifications to incidental structures such as monitoring wells, culverts, curbs, gates, and subdrains to accommodate revised grading.

- Identification and isolation of sumps and subsurface drain systems, which had discharged into the surface water system, and construction of new groundwater interceptors (i.e., swale underdrains intended to reduce the exfiltration of overburden groundwater in the swales), discharges from the existing and new sumps and subsurface drain systems were pumped to tanks T-1101 and T-1102 and directed to the WTP for treatment prior to discharge under the SPDES permit.

- Construction of surface water containment and/or storage systems for areas on the northern portion of the Site which could not be effectively covered or remediated.

- Sampling of impervious building surfaces such as roofs and walls and decontamination of building surfaces when determined necessary based on the sampling results.

- Implementation of a surface water monitoring program to confirm the effectiveness of the cover activities.

Figure I4.2 identifies the limits of the North Site Cover and Figure I4.3 identifies the locations of all existing groundwater interceptors (shallow drains and sumps) at the Facility. Table 4.2 lists and describes the purpose for the groundwater subdrains/sumps currently at the Facility.

The Description of Current Conditions Report (CRA 1991) and the North Site Cover Construction Report (CRA 1989b) describe the detailed design and construction of the North Site Cover, the subsurface drains/sumps, and other pre-closure activities. The North Site Cover and the associated groundwater interceptor drains have been inspected, maintained, and/or operated in accordance with a North Site Cover Operation and Maintenance (O&M) Program.

After completion of the North Site Cover, FMC monitored the surface water quality to assess the effectiveness of the pre-closure activities. Monitoring performed to date has demonstrated that the North Site Cover and the pre-closure activities have had a positive impact on the surface water quality of the northern half of the Facility by reducing the constituent concentrations in the surface water runoff from the northern

half of the Facility to below regulatory toxicity characteristic hazardous waste levels. Secondary benefits of the North Site Cover and the overburden groundwater interceptors include the following:

- The low-permeability cover reduced surface water infiltration into the underlying overburden soil.

- Ongoing pumping of swale underdrains and sumps along the northern boundary of the Facility has created a hydraulic barrier to horizontal groundwater in the overburden and controls any off-Site migration of impacted overburden groundwater.

- North Site Cover effectively minimizes casual direct contact of potentially impacted soils by workers at the Facility and prevents the off-Site migration of impacted surficial soils via the air pathway (i.e., wind erosion).

While successful, the North Site Cover, subdrains, and other preclosure activities have not sufficiently reduced constituent concentrations in the runoff from the northern half of the Site to consistently allow the discharge from the Facility without treatment. Surface water runoff from the North Site Cover is currently collected in the retrofitted WSI prior to treatment by the WTP and discharged to Tributary One under the terms and conditions of the Facility's SPDES permit.

4.3 Sanitary Sewer Replacement

In 1981, the sanitary sewer was replaced to eliminate groundwater infiltration into the sewer line. The new sanitary sewer was constructed of Furan® (resin composite welded steel) pipe with sealed joints. An underdrain and sump was installed along a section of the sewer line near the northwest corner of the Facility (see Figure I4.3) prior to the sanitary sewer connection to the Middleport sewer system. The underdrain and sump system collects groundwater along the sewer bedding and controls any off-Site migration of impacted groundwater along the sewer. Collected groundwater is treated at the Facility water treatment plant.

4.4 Closure of Unused Deep Well

A deep bedrock well was located near the south end of the ESI (see Figure I2.9). As discussed in Section 2.5.1, the well was installed in 1968 for waste disposal purposes but was never used. The bottom of the well was approximately 3,189 feet

bgs. The well was screened from 2,655 feet to 3,189 feet bgs. Closure activities for the deep well took place from October through December 1986 and included removal of the well surface structure, grouting and permanently sealing of the well. Documentation associated with the deep well permitting and closure is presented in Appendix 2D.

4.5 Surface Impoundment Closures

In 1985, the NYSDEC notified FMC that the WSI, CSI, and ESI were considered RCRA-regulated hazardous waste storage/treatment units under federal RCRA and State (6 NYCRR Part 373-3) regulations. FMC subsequently prepared and submitted a RCRA Part B hazardous waste permit application (CRA 1985) to the USEPA and a 6 NYCRR Part 373 hazardous waste permit application (CRA 1986a) to the NYSDEC for the ongoing operation of the three surface impoundments and five container storage areas. In 1986, FMC submitted a pre-closure activity plan and plans for closure of the three surface impoundments.

Following substantial completion of the pre-closure activities (as described in Section 4.3), FMC initiated closure activities for the WSI and CSI in September 1988 and April 1989, respectively. Closure activities were performed in accordance with the Plan of Closure: Surface Impoundments (CRA 1988a), which was conditionally approved by the NYSDEC by letter dated May 27, 1988. Subsequent modifications to the plan of closure for each of the impoundments were made and approved or directed by the Agencies. The ESI was taken out of service and isolated in 1988; and since that time it has not received any stormwater runoff from the Facility other than precipitation that falls directly into the impoundment. To date, with concurrence from the Agencies that closure should be postponed until completion and approval of the RCRA Corrective Action process, FMC has not implemented the closure plan. Additionally, FMC used a portion of the ESI and adjacent areas for placement of soils and other materials excavated in the course of a series of interim measures pursuant to fill plans submitted and approved by the Agencies from 1987 to 2007, and submitted an application to designate and manage the eastern portion of the Facility as a CAMU in March 2008.

4.5.1 Partial Closure of Western Surface Impoundment

In August 1988, FMC proposed a modification to the WSI closure implementation schedule presented in the Plan of Closure: Surface Impoundments (CRA 1988a) to perform the closure of the WSI in two phases. The first phase included removal and

replacement of the original liner. FMC proposed to defer remaining closure activities, including placement of backfill and cover material, until FMC could evaluate the effectiveness of the pre-closure activities at the Site. The NYSDEC approved FMC's request for an extension of time to allow closure to be performed in two phases with the second phase to commence no later than March 12, 1990. FMC subsequently submitted Modifications to the Plan of Closure for WSI (CRA 1990) to allow for the following:

- Continued use of the WSI for storage of non-hazardous stormwater runoff for possible treatment prior to discharge to ensure that the discharge limits of the Facility's SPDES permit are met;

- Continued operation of the WSI underdrain system which, together with the sanitary sewer underdrain has created a hydraulic depression in the shallow bedrock in the northwestern quadrant of the Site by collecting groundwater from on- and off-Site areas; and

- Availability of the WSI for possible use for emergency containment of potentially impacted waters in the event of an incident such as application of water during a fire.

Subsequently, the 1991 AOC authorized the use of the WSI as an ICM for control, containment and collection for treatment of contaminated stormwater runoff with several conditions specified in the AOC, including the continued operation of the WSI underdrain system and monitoring of the WSI contents and development of a contingency plan (which will be implemented in case the WSI is found to contain hazardous waste). The AOC also states that FMC may submit a closure plan modification for the WSI to the NYSDEC for its review and approval pursuant to 6 NYCRR 373-3.7 following evaluation of the results of the RFI/CMS.

The first phase of the WSI closure activities was performed in 1988 and included:

- The WSI was temporarily taken out of service to facilitate the closure activities.

- Sampling of in situ sediments for waste characterization purposes and procurement of off-Site disposal approvals.

- Dewatering/solidification of sediments with water content unsuitable for landfilling, and removal and disposal of stone and soil/sediments and existing liner material at Chemical Waste Management's (CWM's) Model City, New York landfill. The material was classified as non-hazardous (based on EP toxicity for arsenic) but, for precautionary reasons, was managed by FMC as if it was hazardous and placed in a secure landfill cell. A total of 609 tons of material was disposed.

- Renovation of the WSI consisting of the removal of the original 1977 liner, installation of a new filter fabric, a new Hypalon liner, and placement of a 4-inch layer of clean stone over the base of the new liner.

The WSI closure activities were completed in September and October 1988. The report titled Final Construction Report, Interim Closure, Western Surface Impoundment (CRA 1989e) describes the activities performed during the WSI closure.

FMC is currently operating the WSI underdrain system and using the WSI as a non-hazardous stormwater retention basin under the terms and conditions of the AOC and the WSI Operations Plan (CRA 1994e). The beneficial effects of the ongoing operations of the WSI underdrain and the WSI include the following:

- Groundwater hydraulic monitoring data indicate that the pumping of the WSI underdrain system has proven to be an effective hydraulic barrier to off-Site overburden and shallow bedrock groundwater flow in the northwest quadrant of the Site.

- The WSI enables the collection and on-Site treatment of surface water from the northern half of the Facility at the WTP prior to discharge to Tributary One.

4.5.2 Closure of the Central Surface Impoundment

From May through September 1989, FMC implemented closure of the CSI, under RCRA standards. These closure activities consisted of the following:

- The CSI was taken out of service and dewatered.

- Sampling and analysis of the soil and sediment from the base of the CSI was conducted to characterize the waste and procure disposal approvals.
- Soil/sediment was excavated to bedrock, and 2 inches of compacted stone base material was placed over the entire base of the CSI.
- The excavated sediment and base material was disposed of at the CWM Model City, New York secure landfill as a characteristic hazardous waste (EP toxicity for arsenic).
- A low-permeability final cover was constructed over the CSI and consisted of:
  - Placement and grading of 14,600 cubic yards of backfill soil.
  - Construction of a 12-inch-thick clay layer.
  - Placement of a 6-inch-thick layer of topsoil.
  - Seeding and mulching of the cover.

The report titled Final Construction Report, Closure of the Central Surface Impoundment (CRA 1989c) summarizes the CSI closure activities.

FMC maintains the cover of the CSI in conjunction with the North Site Cover O&M Program. Closure of the CSI has reduced surface water infiltration into the underlying bedrock. In addition, the CSI cover minimizes any casual contact by workers at the Facility with any impacted groundwater beneath the cover.

4.5.3 Eastern Surface Impoundment Soil Deposition Areas

The ESI was taken out of service in 1988 and has since only received precipitation that falls directly within its limits. Although FMC submitted a closure plan for the ESI to the NYSDEC in 1986, the ESI has not been closed pending completion and implementation of the final corrective measure program for the Facility. The Agencies have concurred with this deferral. Excavated soils from several IRM and/or ICM projects have been deposited adjacent to and within the limits of the ESI (see Figure I4.2). These projects consist of the following:

- 1987-1988 Northern Ditches IRM, which resulted in the construction of an encapsulated soil storage unit (SWMU #53) containing approximately 1,680 cubic yards of soil/sediment excavated from the Northern Ditches.

- 1996 Roy-Hart School Bleacher Area IRM, which resulted in the excavation of approximately 2,200 cubic yards of soil from the Roy-Hart School Bleacher Area and placement of the excavated soil in the ESI Fill Area (also referred to as SWMU #54 - ESI Soil Deposition Area, adjacent to SWMU#53).

- 1999-2000 Roy-Hart School Football Field Area ICM, which resulted in the excavation of approximately 39,000 cubic yards of soil from the southwestern portion of the school property and placement of the excavated soil in SWMU #54.

- 2003 West Properties ICM, which resulted in the excavation of approximately 15,000 cubic yards of soil from the West Properties ICM Area and placement of the excavated soil in SWMU #54.

- 2005 Phase 1 ICM for the North Railroad Property which resulted in the excavation of approximately 16,000 cubic yards of soil from the Phase 1 ICM Area and placement of the excavated soil in SWMU #54.

- 2007 Early Actions, which involved the excavation of approximately 22,000 cubic yards of soil from the Wooded Parcel north of the Facility, 10 residential properties south of Park Avenue and east of Maple Avenue, and properties along open ditch sections of Culvert 105 south of Sleeper Street and north of the Erie Canal, and placement of the excavated soil in SWMU #54.

All soil and subsurface materials (i.e., sewer pipe) placed in the SWMU #54 (ESI Fill Area or ESI Soil Deposition Area) were determined to be non-hazardous wastes. The approximately 1,680 cubic yards of soil/sediment excavated from the Northern Ditches were identified as characteristic hazardous waste based on regulatory-required testing that applied at that time, but these materials were placed within an encapsulated unit (SWMU #53) outside the bounds of the former ESI (SWMU #50). Following placement and grading of the excavated materials placed in the ESI Soil Deposition areas, a temporary soil cover consisting of a nominal 6-inch-thick layer of clean fill was placed over the graded materials and seeded. FMC has proposed that the ESI Fill Area (SWMU #54) become part of a CAMU that has been proposed for the eastern portion of the Facility. The proposed CAMU would be located on the

eastern portion of the FMC Facility for the permanent management of contaminated soil and debris generated by remediation projects performed as part of FMC's RCRA Corrective Action program. An application for the proposed CAMU was submitted to the Agencies in March 2008.

4.6 North Railroad Property Remedial Activities

As discussed in Section 2.2, FMC purchased the North Railroad Property (8.06 acres) along the northern boundary of the Facility in May 2002 (see Figure I2.3). The North Railroad Property includes the:

- "Northern Ditches," which includes the drainage ditches that run east to west along the north and south sides of the active mainline railroad tracks.
- "Northwest Conrail Area," the eastern three quarters of which was covered with a temporary soil cover in late 2002 and enclosed by extending the Facility's security fence.
- Approximately 2,700 feet of railroad track and bedding.

Prior to May 2002, the North Railroad Property was last owned by Conrail. Falls Road Railroad currently operates and maintains the railroad track and appurtenances on the North Railroad Property. Section 3.2 summarizes the investigation history for the North Railroad Property.

FMC completed the following remedial activities on the North Railroad Property before and after it acquired the property in 2002:

- 1987-1988 Northern Ditches IRM.
- 2002 Northwest Conrail Area Temporary Cover and Fencing.
- 2003 Northern Ditches Maintenance and Fencing.
- 2005 Phase 1 North Railroad Property ICM that addressed the portion of the North Railroad Property, exclusive of the Northwest Conrail Area.
- ongoing inspection, maintenance and monitoring of the Phase 1 ICM.

These activities are further described below. In addition, in 1996 and 1999, during implementation of the Bleacher Area IRM and Football Field ICM at the Roy-Hart School Property, portions of the Northern Ditches drainage ditch on the north side of the North Railroad Property were excavated. Sections 3.9 and 3.10 present detailed discussions of the IRM and ICM performed at the Roy-Hart School Property. As discussed below, FMC intends to implement a Phase 2 North Railroad Property ICM in 2008.

4.6.1 1987 – 1988 Northern Ditches IRM

In 1987, the NYSDEC and NYSDOH requested that FMC install a security fence around the Northern Ditches to limit access from the school property by students and others. In lieu of constructing a fence around the Conrail property, FMC proposed to excavate and replace surficial soil/sediment from the ditches.

The Northern Ditches IRM was initiated in December 1987 after obtaining required property access agreements, and was completed in June 1988. The program was performed in accordance with the terms and conditions of an Order on Consent (File No. 87-49) between the NYSDEC and FMC (NYSDEC and FMC 1987). IRM activities included the following:

1) Construction of a lined soil deposition area (later designated as SWMU #53) for the encapsulation of soil/sediment from the excavated Northern Ditches on the FMC Facility south of the ESI (see Figure I4.4) which consisted of:

   - 40-mil high-density polyethylene (HDPE) underliner over a 12-inch-thick compacted clay layer.

   - Placement of a nominal 4-inch-thick layer of clay over the soil/sediment excavated from the Northern Ditches.

   - 40-mil HDPE overliner placed over the 4-inch clay layer and fused to the HDPE underliner along the entire perimeter of the storage area.

   - Clay and topsoil cover was placed over the HDPE overliner and seeded.

2) Construction of railroad crossing by Conrail.

3) Excavation and restoration of the invert of the ditch south of the railroad tracks (between December 14, 1987 and December 29, 1987).

4) Excavation and restoration of the invert of the ditch north of the railroad tracks (May 9 to May 19, 1988).

5) Closure of the soil deposition area which contained approximately 1,680 cubic yards of soil/sediment excavated from the Northern Ditches.

Specific excavation and restoration activities consisted of removal and disposal of vegetation, isolation of the ditch by excavation of a minimum 8-inch depth of sediment/soil from the south ditch invert and 8 to 12 inches of sediment/soil from the north ditch invert, transportation and placement of excavated material in the soil storage area, collection of confirmatory soil samples from the excavation base for analysis of arsenic and lead, placement of a geotextile fabric on the excavation surface, and backfilling of the excavated area with a minimum of 6 inches of clay and 2 inches of stone. A stable vegetative cover was re-established adjacent to the Northern Ditches.

Soil excavated from the Northern Ditches was placed in an engineered storage area (designated SWMU #53) outside the southern bounds of the former ESI in accordance with the 1987 Consent Order (NYSDEC and FMC 1987).

The IRM program was effective in preventing off-Site migration from the subsurface via surface water based on surface water sampling conducted during the 1990-1993 OSI. The soil cover in the ditches reduced possible public exposure to impacted subsurface soil underneath the soil cover.

4.6.2 2002 Northwest Conrail Area Temporary Cover and Fencing

By letter dated June 25, 2002, FMC submitted a scope of work to install a temporary soil cover over the eastern portion of the Northwest Conrail Area and to extend its Facility fence around the grass-covered portion of the Northwest Conrail Area. FMC completed the work during the fall of 2002. Low areas were filled with clean fill soil. A 4-inch layer of clean imported topsoil was placed over the eastern three quarters of the grass-covered portion of the Northwest Conrail Area and was graded and hydro-seeded. A new fence was installed around the grass-covered portion of the Northwest Conrail Area to prevent public access. A summary description of these activities was

provided to the Agencies by letter dated February 13, 2003. Copies of the June 25, 2002 and the February 13, 2003 submittals are contained in the Technical Report on Data Sufficiency for the North Railroad Property (BBL 2005b).

4.6.3 2003 Northern Ditches Maintenance and Fencing

By email dated July 3, 2003, FMC submitted a draft scope of work for proposed fencing and maintenance activities for the Northern Ditches. The scope of work was later revised to incorporate comments from the Agencies and the revised scope of work was contained in the October 2003 RFI/CMS Work Plan for the North Railroad Property. Consistent with the scope of work, FMC performed the following inspection and maintenance activities in November and December 2003:

- The existing fence (owned by the Roy-Hart School District) around the football field and track area was extended eastward to the school's eastern fenceline and westward just beyond Culvert 105. The fence was intended to restrict public access to the North Railroad Property and to minimize the potential for public contact with soils in the north ditch. The fence is situated on the Roy-Hart School Property and on the vacant eastern lot of the North Commercial/Industrial Area (not owned by FMC).

- Woody vegetation within the ditches was removed from the clay cover installed at the bottom of the ditches.

- Other vegetation within and along the ditches was removed to facilitate inspection of the Northern Ditches and to permit installation of the fence.

- Soil piles next to any animal burrows were removed and the animal burrows were filled with a flowable concrete and sand mixture.

- Portions of the clay cover within the bottom of the ditches were repaired as necessary.

- The Northern Ditches were inspected as specified in the Northern Ditches Inspection & Maintenance Scope of Work that was included in the October 2003 North Railroad Property RFI/CMS Work Plan (CRA 2003e).

Semi-annual inspection and maintenance of the Northern Ditches continued to be performed in 2004 and early 2005, until completion of the 2005 Phase 1 North

Railroad Property ICM. At the request of the Agencies, FMC posted property signs along the north and south property boundaries of the North Railroad Property from July 2004 through mid 2005. One sign stated “Caution, Unauthorized Personnel Keep Out” and another stated “FMC Property, Call 735-3761, ext 281 With Questions.”

4.6.4 2005 Phase 1 North Railroad Property ICM

FMC evaluated and proposed remedial alternatives for the North Railroad Property in late 2004. In January 2005, the Agencies determined that an ICM was necessary on the North Railroad Property. FMC agreed to perform an ICM for the North Railroad Property in two phases. The first phase pertained to the portion of the North Railroad Property that was situated outside of FMC’s Plant security fence (as in place in early 2005) and excluded the grass-covered portion of the Northwest Conrail Area and a 15-foot wide corridor centered along the railroad mainline track and spurs. The second phase would be performed on the grass-covered portion of the Northwest Conrail Area, which had been enclosed with a security fence and covered with a clean soil cover in 2002 (see Section 4.7.2). The two phases of the ICM were intended to be a containment-type remedial alternative that could be acceptable as a “final corrective measure” and that would be consistent with the design of the existing North Site Cover.

From February through June 2005, FMC and the Agencies discussed the scope of work and the final design for the Phase 1 ICM. FMC submitted a Phase1 ICM Work Plan for the North Railroad Property in June 2005 (BBL 2005d). The Agencies subsequently approved the work plan with revisions.

The Phase 1 ICM was implemented from June 2005 through September 2005 and included removal of soil and sediment, and construction of a surface cover (BBL 2005d). The Phase 1 ICM activities were performed consistent with the provision of the operating easement held by Falls Road Railroad Company, and in compliance with the railroad safety standards and requirements.

The Phase 1 ICM remediation area (see Figure I4.5) is approximately 6.3 acres in size and is traversed by an active railroad track operated by Falls Road Railroad Company and by stormwater drainage ditches on the north and south sides of the track. The Phase 1 ICM Area includes a concrete pad/platform portion of the Northwest Conrail Area that is situated outside of the FMC Plant security fence. The Phase 1 ICM Area excludes an approximately 15-foot-wide buffer along the railroad

main line and spurs (i.e., approximately 7.5 feet from the centerline on either side of the tracks).

The Remedial Action Objectives (RAOs) for the Phase 1 ICM were to:

- Minimize the potential for migration of Site-related constituents of concern (COCs) via erosion of soil/sediments and transport of suspended soil/sediments within surface water to off-Site areas (e.g., Culvert 105 storm sewer and Tributary One).

- Minimize the potential for human contact with impacted media present at the Site based on the current and reasonably expected future land use for commercial/industrial purposes.

- Minimize the potential for exposure of wildlife to impacted media within the Site based on the current and reasonably expected future land use for commercial/industrial purposes.

The Phase 1 ICM construction activities included:

- Abandonment of an existing culvert that crosses beneath the railroad main line (a new culvert was constructed by Falls Road Railroad Company, prior to implementation of the Phase 1 ICM construction work, at a location east of the FMC-owned North Railroad Property).

- Excavation and removal of a minimum of 2 feet of soil and sediment from the portion of the Phase 1 ICM area situated on the north side of the mainline railroad tracks and the construction of a 2-foot-thick soil cover, consisting of (from bottom to top): a geosynthetic clay liner (GCL), a 1-foot-thick layer of sand, a non-woven geotextile layer, and a 1-foot-thick layer of stone.

- Excavation and removal of soil and sediment to depths necessary to facilitate construction of a surface cover on the south side of the railroad tracks and the construction of a 2-foot-thick soil cover consisting of (from bottom to top): a GCL, an 18-inch-thick layer of general fill, a non-woven geotextile layer, and a 6-inch-thick layer of stone.

- Implementation of stormwater management controls.

- Transportation, placement, and grading of excavated materials into the ESI Fill Area located at the FMC Plant.

- Installation of a new security fence on the south side of the railroad tracks. The fence was installed a minimum of 12 feet south of the mainline railroad tracks.

- Post-construction maintenance and/or monitoring activities.

As a result of the Phase 1 ICM activities, surface water runoff from the portion of the North Railroad Property on the south side of the mainline railroad tracks drains to the WSI and is treated and discharged pursuant to the Facility's SPDES permit. Surface water runoff from the portion of the North Railroad Property on the north side of the mainline railroad tracks, as well as surface water runoff from properties abutting the North Railroad Property to the north and east and from wooded land and farm fields abutting the eastern boundary of the Site, now drains to Culvert 105 via the reconstructed North Ditch (including a new culvert installed east of the North Railroad Property under the railroad track).

The Phase 1 ICM activities are summarized in the Construction Report for the North Railroad Property Phase 1 Interim Corrective Measures (BBL 2006c), which was submitted to the Agencies in January 2006.

FMC is currently inspecting, monitoring and maintaining the Phase 1 ICM cover in accordance with the approved Phase 1 ICM OM&M Plan (BBL 2006e). A summary of the activities performed as part of the Phase 1 ICM OM&M Plan is presented in the quarterly progress reports for the Facility.

4.6.5 Proposed Phase 2 North Railroad Property ICM

As discussed above, FMC agreed to perform an ICM for the North Railroad Property in two phases, and completed the Phase 1 ICM construction activities in 2005. The Phase 2 ICM will be performed in the grass-covered portion of the former Northwest Conrail Area (NWCA) in the northwest corner of FMC's Middleport Facility plant site (see Figure I4.5). The Phase 2 ICM area is situated within the Facility's security fence and had been covered with a clean soil cover in 2002 (see Section 4.7.2). FMC and the Agencies discussed the scope of work, the design and the ICM work plan for the Phase 2 ICM in 2005 through 2007. In May 2007, FMC submitted the Phase 2 Interim Corrective Measures Work Plan for the North Railroad Property (ARCADIS

BBL 2007b). By letter dated June 26, 2007, the Agencies approved the Phase 2 ICM Work Plan, except for Section 4.8 "Task PC8 - Post-Phase 1 ICM Stormwater Management Control" and Appendix H "Assessment of Post-Phase 1 ICM Stormwater Run-off Conditions." The May 2007 Phase 2 ICM Work Plan proposed completion of Phase 2 ICM construction activities in 2007. However, FMC could not complete the Phase 2 ICM during the 2007 construction season (as discussed in FMC's letter dated October 31, 2007) due to access and scheduling difficulties associated with National Grid power poles located in the Phase 2 ICM area and due to the impending cold weather (which would present technical difficulties for the installation of the HDPE liner). National Grid required relocation/replacement of three power poles within the Phase 2 ICM area. The Agencies subsequently approved the change to the Phase 2 ICM construction schedule. FMC reached agreement with National Grid for replacement of the three power poles in late 2007 and the poles were replaced by National Grid in April 2008. FMC intends to conduct the approved Phase 2 ICM construction activities in 2008.

4.7 Groundwater Extraction and Containment Systems

The groundwater remedial systems at the Facility are being operated as ICMs under the terms and conditions of the AOC. The ICMs were constructed for hydraulic containment and recovery of impacted groundwater in the overburden and bedrock beneath the Site in a phased approach. As of the end of 2007, the groundwater remedial systems at the Site were as follows:

1) Operation of the WTP at the Site.

2) Sanitary sewer underdrain collection system (Sump 1) (see Figure I4.3), which prevents off-Site migration of contaminated groundwater along the sewer bedding.

3) Engineered asphalt and clay cover installed over the northern half of the site to minimize infiltration.

4) Approximately 1,500 linear feet of underdrains and associated sumps (Sumps 2, 4, 5, and 15) that run along the north-central boundary of the Facility and other minor sumps and drains that collect overburden groundwater from beneath the northern half of the Site (see Figure I4.3).

5) Underdrains and sump system (Sump 3) under the WSI for interception and control of off-Site groundwater migration along the Site's northwestern property boundary.

6) Blast-fractured bedrock migration control collection Trench A (approximately 300 feet in length) and extraction well A-756X for interception of shallow bedrock groundwater and control of off-Site groundwater migration along the Site's northeastern property boundary.

7) Approximately 2,300 feet of blast-fractured bedrock migration control collection trenches and three extraction wells for interception of shallow bedrock groundwater and control of off-Site groundwater migration along the Site's northern property boundary consisting of:

    - Trench B (approximately 200 feet in length) and extraction well A-758X.
    - Trench C (approximately 820 feet in length) and extraction wells C-EX1, A-759X, and C-EX2.
    - Trench D (approximately 480 feet in length) and extraction wells A-760X, D-EX1, and D-EX2.
    - Trench G (approximately 790 feet in length) and extraction wells G-EX1, G-EX2, and G-EX3.

8) Blast-fractured bedrock source recovery collection Trench E (approximately 275 feet in length) and Trench F (consisting of four short spurs totaling 150 feet in length) and associated extraction wells A-757X and A-542RX, respectively, for recovery of impacted shallow bedrock groundwater at source areas in the interior of the Site.

9) Deep bedrock extraction well BC-752X for recovery of impacted groundwater at source areas in the interior of the Site.

Figure I4.7 depicts the groundwater ICMs installed through 2007. The effectiveness of the groundwater ICMs are routinely monitored and evaluated as part of the Facility's GMP and supplemental hydraulic performance assessments, in accordance with the terms and conditions of the AOC.

The subsections below describe the various phases of the groundwater ICMs.

4.7.1 1987 – 1993 Groundwater Extraction Wells

During the 1985-1986 SI and subsequent groundwater monitoring events, elevated concentrations of methylene chloride were detected in groundwater in the northeast quadrant of the Facility. As a result, FMC developed and constructed a bedrock groundwater extraction well system in 1987 as part of a phased approach for the remediation of groundwater beneath the Facility.

The primary objective of this groundwater extraction system was to contain or control off-Site migration of methylene chloride in the groundwater beneath the Facility and to begin removal of the methylene chloride mass. The system was designed to meet this objective by extracting groundwater at the Facility perimeter and from known methylene chloride impacted zones within the Facility.

The groundwater extraction well system was designed based primarily on hydrogeologic and groundwater quality data obtained during the SI. Four extraction wells were installed during this initial phase. Three of the wells were installed in areas with elevated methylene chloride concentrations to begin to control the source of methylene chloride. A fourth well (well R-754) is located along the northern limit of the Facility to contain this compound within the geographical limits of the Facility. Figure I4.6 illustrates the locations of these extraction wells.

The groundwater extraction system constructed in 1987 consisted of the following major components:

- Four deep bedrock extraction wells with open bedrock intervals of 43.5 to 60.9 feet.
- Pump houses containing pump controls, flow control, flow metering equipment, and electrical equipment.
- Buried forcemains (which were subsequently replaced by an aboveground heat-traced and insulated forcemain).
- Tank truck and railroad tank car loading Facility.

Operation of the groundwater extraction system began in February 1988. Initially, extracted groundwater was transported and disposed of at off-Site Treatment, Storage, or Disposal Facilities (TSDFs) in accordance with applicable rules and regulations. In 1988, FMC requested modification of its SPDES permit for the discharge of treated (WTP) groundwater from the extraction well system. This modification was approved in 1992. Since 1991, after execution of the AOC, the groundwater extraction well system has been operated as an ICM in accordance with the terms and conditions of the AOC.

During the period of 1988 to 1994, the effectiveness of the groundwater extraction well system was routinely monitored and evaluated. The average combined yield from the four bedrock extraction wells was less than 3 gallons per minute (GPM). Table 4.3 summarizes the volume of groundwater pumped by the system and the estimated mass of constituents removed from the bedrock aquifers. In response to the Agencies' request for an Additional Interim Corrective Measure (AICM) to address off-Site groundwater north of the Facility, FMC evaluated the groundwater extraction system which included the performance of pumping tests and submitted an AICM Work Plan (CRA 1992) to the Agencies. It was concluded that the operation of the extraction well system resulted in a very limited groundwater capture zone immediately around each extraction well because of the low transmissivity of the fractured bedrock beneath the Facility, and that some form of enhanced bedrock groundwater recovery would be more effective (CRA 1992). Accordingly, in 1992, FMC proposed to develop a pilot scale program to evaluate the feasibility and effectiveness of the use of blast-fractured trenches (see Section 4.8.2).

Currently, one of the four original groundwater extraction wells (R-752, renamed BC-752X) is operating as originally designed. Two extraction wells have been modified to be monitoring wells (R-753 renamed A-753A, and AB-755 renamed as A-755A) and one extraction well (R-754) was decommissioned and closed as part of subsequent blast-fractured trench installation programs.

4.7.2 1994 – 1995 AICM Blast-Fractured Bedrock Trench Pilot Study

In 1992, FMC proposed to evaluate the feasibility and effectiveness of using blast-fractured bedrock trenches to enhance groundwater recovery and expand the groundwater capture zone in the impacted shallow bedrock areas at the Facility in response to the Agencies' directive to propose an AICM Work Plan (CRA 1992), which was submitted to the Agencies in accordance with the AOC.

In early 1993, FMC submitted an AICM Pilot Study Work Plan (CRA 1993a) which proposed the design, construction, and testing of a blast-fractured trench along the northeastern Facility boundary where elevated methylene chloride concentrations had been detected off-Site. After receipt of Agency approval of the AICM Pilot Study Work Plan, FMC began implementation of the Pilot Study in January 1994. The Pilot Study activities included:

- Linear controlled blasting of a 300-foot long trench (Trench A) in the shallow bedrock to depths approximately 25 to 32 feet bgs, keying into the Cambria Formation (which is a low permeability formation).
- Decommissioning of bedrock extraction well BC-753 and conversion to a monitoring well (A-753A).
- Construction of a groundwater recovery well (A-756X) into the fractured trench and pump house.
- Modification of the existing groundwater extraction forcemain.
- Performance of short-term pumping tests on Trench A.
- Performance of an effectiveness monitoring program during the continuous pumping from the Trench A recovery well.

Long-term operation of the Trench A groundwater extraction system began in April 1994. Hydraulic monitoring data obtained indicates that the operation of the blast-fractured Trench A groundwater recovery system has reversed the groundwater hydraulic gradient along the eastern property boundary, controlling off-Site migration and removing methylene chloride and other Site-related constituents in the shallow bedrock within the capture zone. The capture zone for Trench A extends approximately 400 feet in the north-south direction and approximately 600 feet to the east. Long-term operation of the Trench A groundwater collection system has reduced methylene chloride concentrations in monitoring wells east of the Site to non-detectable levels. The average combined yield from the Trench A extraction system (A-756X) and the three remaining bedrock extraction wells (BC-752X, BC-754X, AB755X) in 1994 and 1995 was approximately 4 GPM. Table 4.3 summarizes the volume of groundwater pumped from Trench A and the mass of constituents removed.

4.7.3 1996 – 1997 Phase II AICM

Based on the success of the Phase 1 AICM pilot study, FMC proposed and, following approval by the Agencies, implemented the phased installation of a series of hydraulic containment and source control blast-fractured bedrock trenches and extraction well systems in the northern half of the Site (AICM Phase II Bedrock Groundwater Migration Control Trench Implementation Work Plan [or AICM Phase II Work Plan] [CRA 1994f]).

In accordance with the approved AICM Phase II Work Plan (CRA 1994f) and subsequent modifications, the AICM Phase II work tasks were performed from mid-1995 through mid-1996, and consisted of the following:

1) Hydraulic control and contaminant recovery trenches pre-design activities were implemented from June 20 to July 31, 1995 and consisted of the installation and testing of five piezometers, data interpretation and design of hydraulic control Trench B and source control Trench E, and submittal of the design for Trenches B and E.

2) Construction of Trenches B (200-foot long) and E (50-foot long) (as shown on Figure I4.7) was performed from August 16 to September 8, 1995 and included linear controlled blasting of bedrock Trenches B and E, installation of extraction wells A-758X and A-757X for Trenches B and E, respectively, and installation of piezometers in Trenches B and E.

3) Short-term testing and monitoring of Trenches B and E, including the performance of 48-hour pumping tests on Trenches B and E from September 20 to October 2, 1995.

Relocation of pumping equipment in former extraction well AB-755 which included:

1) Conversion of monitoring well A-542 to an 8-inch diameter cased extraction well (A-542X) with a depth of 29 feet.

2) Conversion of extraction well AB-755 to monitoring well A-755A by back grouting.

3) Transfer of the pump equipment and controls.

4) Replacement of existing forcemains and installation of new forcemain and pump controls to Trenches B and E and new extraction well A-542X from October 1995 to February 1996.

5) Continuous pumping and long-term effectiveness monitoring of Trenches B and E starting in March 1996.

6) Installation and monitoring of a piezometer west-southwest of Trench B to better define the hydraulic impact of the trenches in this area beginning in October 1996.

7) Performance monitoring of groundwater monitoring well water levels during the continuous pumping of Trenches B and E, starting March 1996.

The Additional Interim Corrective Measures: Phase II Bedrock Groundwater Migration Control Trench Installation Summary Report (Installation Summary Report) (CRA 1996a), issued to the Agencies on May 3, 1996, describes the construction activities and the results of the short-term effectiveness monitoring activities.

The average combined yield from the Trench A (A-756X), Trench B (A-758X), and Trench E (A-757X) collection systems, new extraction well A-542X and the two remaining bedrock extraction wells (BC-752X and BC-754X) in 1996 and 1998 was approximately 6 to 8 GPM Table 4.3 summarizes the volume of groundwater and the mass of constituents removed during 1996-1998.

4.7.4 1998 – 1999 Phase II AICM

As part of the remaining Phase II AICM tasks in the Phase II Work Plan, the effectiveness of Trenches B and E was evaluated after a minimum of six months of continuous pumping. Based on that evaluation, additional bedrock migration control trenches were recommended and designed. In addition, in April and May 1997, FMC installed and sampled five new bedrock monitoring wells at the Facility to identify other possible locations for bedrock groundwater source control trenches.

In April 1998, FMC submitted a Trenches B and E Evaluation and Proposed Trenches Design report (CRA 1998a) which contained an effectiveness evaluation of Trenches B and E, and the design and proposed installation activities for four new trenches (Trenches C, D, E extension, and F). The Agencies subsequently approved the report with some modifications. Installation of the new blast-fractured trenches

(see Figure I4.7) and the associated pumping systems and forcemains began in July 1998 and were substantially completed in March 1999.

The 1998-1999 AICM activities consisted of the following:

- Installation of 820 feet long bedrock groundwater migration control Trench C and trench extraction well A-759X and associated in-trench piezometers.
- Installation of 480 feet long bedrock groundwater migration control Trench D and trench extraction well A-760X and associated in-trench piezometers.
- Decommissioning of bedrock extraction well BC-754X.
- Installation of an additional 225 feet of blast-fractured trench to Trench E and associated in-trench piezometers.
- Installation of contaminant recovery trench F consisting of four short spurs totaling 150 feet in length and the re-drilling of extraction well A-542RX.

The new extraction systems began long-term pumping in March 1999 after completion of the forcemain construction and startup/troubleshooting of the systems. Operations of the seven groundwater extraction well systems as installed in 1998 and 1999 continued through 2004. The average combined yield from the Trench A (A-756X), Trench B (A-758X), new Trench C (A-759X), new Trench D (A-760X), extended Trench E (A-757X), and new Trench F (A-542RX) collection systems and the one remaining deep bedrock extraction well (BC-752X) in 1999 through 2004 ranged from approximately 8 to 13 GPM. Table 4.3 summarizes the volume of groundwater and the mass of constituents removed during this period.

4.7.5 2005 Blasted Trench Extension Project

From September 2000 through April 2004, FMC implemented a phased program to evaluate the hydraulic performance of the groundwater ICMs installed at the Site, which includes the seven bedrock groundwater extraction well systems, the WSI underdrain collection system, and the overburden groundwater collection underdrains and sumps. A chronological summary of the assessment is as follows:

- 1999 through 2000 - FMC submitted to the Agencies the Groundwater Interim Corrective Measures Hydraulic Performance Monitoring Plan (CRA

1999c) dated July 1999. The objective of the plan was to obtain additional data to better assess the hydraulic capture zones affected by the groundwater ICMs. The Agencies approved the plan, with modifications noted, in letters dated August 10, 2000 and September 12, 2000.

- September 2000 through November 2000 – One monitoring well and 27 piezometers were installed along the blast-fractured trenches to supplement the existing hydraulic monitoring well network. The flow meters and pump controls for the extraction wells and the overburden collection sumps were inspected and upgraded/repaired.

- December 2000 through December 2001 – Water levels were measured in approximately 175 monitoring wells and piezometers every other month. Extraction well and collection sump flow rates and pumping volumes were recorded weekly.

- 2002 – In March 2002, FMC submitted the report Groundwater Interim Corrective Measures Hydraulic Performance Monitoring Results (CRA 2002b) to the Agencies. The report identified areas where the performance was uncertain or needed improvement, and recommended that supplemental work be performed to address these areas. FMC submitted the Work Plan for Supplemental Hydraulic Performance Assessment of Groundwater Interim Corrective Measures (Geomatrix 2002b).

- September 2002 through June 2004 - FMC implemented the June 2002 Work Plan beginning in September 2002. The activities included: 1) installation of 10 piezometers in September and October 2002; 2) acid treatment and cleaning of the extraction systems for Trenches A, B, C, and D in October through December 2002; 3) performance of pumping tests in April 2003; and 4) hydraulic monitoring of the well network. The results were presented in the report titled Supplemental Hydraulic Performance Assessment of Groundwater Interim Corrective Measures (Geomatrix 2004a). The report also recommended the implementation of a preventative maintenance program for biological control in the trenches and the addition of new extraction wells to existing Trenches C and D and the extension of Trench D blast-fractured bedrock collection system further to the east. The Agencies provided conditional approval of the report and comments concerning its recommendations in a letter dated June 1, 2004.

Based on the April 2004 report, and responses to the Agencies' comments, in March 2005 FMC submitted the "Work Plan: Trench D Extension, Extraction Well and Piezometer Installations" to the Agencies to expand and upgrade the groundwater ICMs at the Facility. The work plan was approved by the Agencies with modifications by letter dated March 18, 2005. The Work Plan activities were implemented in April through August 2005. The completed 2005 groundwater ICM activities were as follows:

- Installation of four exploratory coreholes and conversion of three of the coreholes to piezometers.
- Installation of a new 790-feet long blast-fractured Trench G east of Trench D. (The new Trench G replaced the proposed 775-foot extension to existing Trench D).
- Re-blasting of the eastern end of Trench D (the Trench D re-blast zone was approximately 190 feet long and was off-set 2 to 3 feet south of the existing blasted Trench D alignment).
- Installation of three new Trench G extraction wells (G-EX1, G-EX2, and G-EX3) and 12 piezometers within and outside of Trench G.
- Installation of two new extraction wells at the west and east ends of Trench C (C-EX1 and C-EX2) and one in-trench piezometer.
- Installation of two new extraction wells at the west and east ends of the Trench D re-blast zone (D-EX1 and D-EX2) and two in-trench piezometers.
- Design and construction of the pumping systems and forcemains.
- Start-up and troubleshooting of the new systems.

A summary of these activities is presented in the 2005 Groundwater ICM Construction & Performance Report (BBL 2005h). The hydraulic performance of the new systems will be summarized in the quarterly progress reports and in Volume VIII of the Revised RFI Report – Groundwater Investigations and Remediation Results.

4.8 1996 Roy-Hart School Bleacher Area IRM

FMC performed an IRM to remove soils containing arsenic and other Site-related chemicals from behind the school bleachers in July and August 1996. This area was designated as Area III by the NYSDOH in 1987 (NYSDOH 1987d) when NYSDEC and NYSDOH recommended fencing to prevent access. The IRM was performed in accordance with the provisions of an Order on Consent between the NYSDEC and FMC (Index No. B9-0221-96-06 IRM) effective July 8, 1996 (NYSDEC and FMC 1996).

The IRM area (hereinafter referred to as "Roy-Hart School Bleacher Area") lies to the south and west of the southernmost bleachers located at the Roy-Hart High School track and football field, excluding the bleachers and area under the bleachers. The Roy-Hart School Bleacher Area is owned by the Roy-Hart School District and lies to the north of the FMC Middleport Facility. Figure I4.8 shows the location of the Roy-Hart School Bleacher Area.

The Roy-Hart School Bleacher Area IRM project consisted of the following activities:

- Preparation of a soil disposition area within the southeastern corner of the ESI (part of the ESI Fill Area).
- Excavation of approximately 2,200 cubic yards of soil from a minimum depth of 2 feet from the Roy-Hart School Bleacher Area and placement of the excavated soil in the ESI disposal area (designated as SWMU #54).
- Closure of the ESI Fill Area which consisted of grading to promote drainage and placement and seeding of a 4-inch layer of topsoil.
- Excavation of an additional approximately 40 cubic yards of soil beneath the haul road at the Roy-Hart School Bleacher Area and disposal of this soil at CWM's Model City, New York secure landfill. Based on the project schedule, this soil was managed for off-Site disposal as a hazardous waste.
- Collection of soil samples from the excavation base to document the arsenic and lead concentrations in the remaining soils.
- Backfilling/restoration of the excavated areas as shown on Figure I4.9.

A summary of the Bleacher Area IRM project is presented in a report titled Bleacher Area Excavation Project, Final Construction Report (CRA 1997). The NYSDEC approved the construction report by letter dated February 12, 1997 (NYSDEC 1997). The NYSDEC issued a Record of Decision, FMC Corporation Operable Unit 4, Bleacher Area, Village of Middleport, Niagara County, Site Number 9-32-014 dated February 1999, for the IRM, finding that the IRM was protective of human health and the environment, complied with applicable or relevant and appropriate requirements (ARARs), and was cost effective.

4.9 1999-2000 Roy-Hart School Football Field Area ICM

By letter dated August 11, 1998, the Agencies provided their determination that an ICM was required and requested that FMC perform an ICM to remove arsenic-containing soil from a defined area (ICM Area) which included the Roy-Hart School football field, track, school bus garage parking lot, and surrounding area (Figure I3.9) (CRA 1999b). As defined by the Agencies, the ICM Area consisted of the "entire area within the following boundaries, except that portion which is currently occupied by buildings:

- Northern Boundary – Designated by a straight line running east to west, located 40 feet to the north of the outside edge of the running track.
- Southern Boundary – Designated by the northern edge of the Bleacher Area IRM and the northern edge of the property owned by Conrail to the east and west of the Bleacher Area IRM.
- Eastern Boundary – Designated by a straight line running north to south, located 40 feet to the east of the outside edge of the running track.
- Western Edge – Designated by the school's western property line.

The Agencies' August 11, 1998 letter stated that the basis and reasons for the determination that "an additional ICM is necessary in the ICM Area described" rest on the arsenic database for surficial soils (0 to 6 inches), the likelihood of contribution from historical operations and events pertaining to the FMC Facility, and the results of the Baseline Human Health Risk Assessment conducted for the USEPA (see Section 3.5.2). The letter stated further that the objective of the ICM is "to remove the soil arsenic contamination from the ICM Area and restore topography and layout of the track, football field and surrounding area, in a timely manner" (Agencies 1998a).

FMC notified the Agencies of its intention to comply with their request by letter dated August 13, 1998 and submitted an ICM Work Plan, dated October 19, 1998, to the Agencies for review and approval. The work plan was subsequently revised 1) to include data from pre-excavation sampling and analysis that provided data for determination of the initial excavation depths; 2) to include the remediation of two areas (ICM Expansion #1 and ICM Expansion #2) adjacent to the Agencies' ICM Area; and 3) to incorporate comments from the Agencies and the public. ICM Expansion #1 was an area approximately 100 feet east and 50 feet north of the northeastern boundary of the Agencies' ICM Area and was included in the ICM to address concerns expressed by the Roy-Hart School District about the levels of arsenic within the area. ICM Expansion #2 was an area east of ICM Expansion #1 and was included to remove soil containing a black material found and soil suspected to contain elevated arsenic concentrations. Figure I4.8 identifies the approximate limits of theses areas on the school property. By letter dated June 24, 1999, the Agencies approved the ICM Work Plan (CRA 1999b), dated May 1999 and revised by letter dated June 9, 1999.

Implementation of the approved ICM Work Plan began on June 14, 1999 and was completed in September 2000 after completion of the new athletic facilities. The excavation of impacted soil was performed during the summer of 1999 while school was out of session. Backfilling activities were completed in the fall of 1999. Construction of the new athletic facilities (i.e., football field, all-weather track, bleachers, lighting, concession stand, fencing, etc.) began in September 1999 and was completed in September 2000, before the start of the new school year. The ICM activities included the following:

- Preparation of project-specific work plans and design drawings.

- Review of the proposed ICM project and FMC work plan at the Agencies' public meeting (held on October 27, 1998). A summary of the public comments and the Agencies' responses to those comments are presented in the Responsiveness Summary for the Royalton-Hartland School Yard Interim Corrective Measure prepared by the NYSDEC, USEPA, and NYSDOH (1999).

- Provision of design drawings and documentation for the new athletic facilities to the Roy-Hart School District for review and approval by the Roy-Hart School District and the New York State Department of Education.

- Collection and analysis of pre-excavation soil samples (467 samples collected in December 1998 and 116 samples collected in April through May 1999) from a 50-foot by 50-foot sampling grid over the proposed ICM excavation area to determine the initial excavation depths. The pre-excavation soil sample data are presented in the approved ICM Work Plan.

- Collection and analysis of soil samples for a surface soil comparison study. Surface soil samples were collected from 0 to 3 inches bgs and 0 to 6 inches bgs at 20 locations on the Roy-Hart School Property for analysis of total arsenic. The data from the surface soil comparison study are presented in the approved ICM Work Plan.

- Procurement of access agreements from the Roy-Hart School District, the owner of the adjacent farm field, and Falls Road Railroad Company (operator of the mainline railroad).

- Qualification of backfill sources including sampling and analysis of backfill materials.

- Removal of above grade structures (i.e., bleachers, press box, goal posts, scoreboard, light poles, concession stand, bleachers) and vegetation (i.e., trees, shrubs).

- Construction of haul roads and railroad crossing, surveying, and installation of erosion controls.

- Excavation of approximately 39,000 cubic yards of impacted soil from the ICM excavation area, (see Figure I4.8) including approximately 300 cubic yards of petroleum impacted soils (determined to be non-hazardous), and placement of the excavated soil in the ESI Fill Area. (Petroleum impacted soil was excavated from an area to the south of the school bus garage and another area to the west of the garage).

- Excavation of approximately 400 cubic yards of petroleum impacted soils for disposal at a permitted off-Site disposal facility by the Roy-Hart School District.

- Collection and analysis of post-excavation soil samples from the excavation base at the same 50-foot by 50-foot sampling grid used during the pre-

excavation sampling program to confirm the final excavation depth. All grid node soil samples collected from the final excavation depths contained less than 30 parts per million (ppm) arsenic.

- Placement of excavated materials in the ESI Fill Area, grading, and construction of a cover over the ESI Fill Area.

- Performance of air monitoring during excavation of soil from the ICM excavation area and handling of excavated soils at the ESI Fill Area.

- Backfilling of the excavation area to the designed final grades.

- Construction of the new athletic facilities (i.e., football field, all-weather track, bleachers, lighting, concession stand, fencing, etc).

- Preparation and submittal to the Agencies of the ICM Construction Report, Roy-Hart School Football Field Area Excavation Project (CRA 2000).

Figure I4.10 presents a photo of the restored athletic facilities and the approximate limits of the ICM excavation area. In addition to the above-described activities, FMC constructed a new lighted baseball field and football/soccer field at the Roy-Hart Elementary School yard in Gasport, New York in 1999 for use by the school district during the 1999-2000 school year, while the ICM construction activities were in progress.

By letter dated May 26, 2000, the Agencies informed the Roy-Hart School District that following performance of the ICM, “the Agencies have determined that the entire school yard is suitable for both athletic and non-athletic uses by all school children, in terms of their exposure to known school yard soil arsenic levels.”

4.10 2003 West Properties Soil and Former Sewer Removal ICM

Based on soil sampling data obtained during the 1993-1996 OSI and the 1996, 1997, and 2002 RFI-related sampling programs and the proximity of the area to FMC’s historic surface water lagoons (SWMUs #5 and #6), FMC proposed an ICM project that involved the removal of a former outfall sewer from the FMC Facility and excavation of soil from portions of 14 residential properties adjacent to the western boundary of the FMC Facility or otherwise traversed by the sewer line (14 West Properties ICM Area). A portion of the former outfall sewer was part of the Village of

Middleport storm sewer system. As previously discussed in Section 2.6.2, the 14 West Properties ICM Area includes 10 residential properties that are situated on the east side of South Vernon Street and abut FMC's western property boundary (south of the mainline railroad tracks and north of Niagara Street); 4 residential properties that are situated on the west side of South Vernon Street and the east side of South Main Street (and that are traversed by the former outfall sewer from FMC); Village of Middleport-owned land (i.e., South Vernon Street right-of-way (ROW) and a section of South Vernon Street traversed by the sewer from FMC) and a strip of FMC-owned land that abuts the ten residential properties (see Figure I4.11). The 14 West Properties ICM Area is situated within a historical surface water migration pathway from the FMC Facility and is located near FMC's former surface water settling lagoons (SWMUs #5 and #6) at the northwest corner of the Facility (see Figure I2.12).

In May 2003, FMC submitted a draft West Properties Soil and Former Sewer Removal Interim Corrective Measures Work Plan (CRA 2003c) to the Agencies, and notified the owners of the affected properties of the proposed ICM. The Agencies informed the public of the proposed ICM in mailings and held a public meeting and availability sessions on June 9 and 10, 2003. The ICM Work Plan was subsequently revised to incorporate comments from the public and the Agencies; to include the excavation of soil from the Niagara Street ROW (FMC-owned land along the north and south sides of Niagara Street) and backfilling of the excavations with clay. A revised ICM Work Plan, dated August 2003, and Addendum No. 1 (dated September 8, 2003) to the work plan were approved by the Agencies.

The ICM preconstruction activities began in June 2003. The ICM construction activities began in August 2003 and were completed in November 2003. The completed ICM activities are described in the Final Construction Report for the West Properties Soil and Former Sewer Removal ICM (Geomatrix 2007b).

The former outfall sewer extended from FMC's western property boundary to South Main Street (see Figure I4.11). The sewer consisted of a stone lined "sluiceway" on the east side of South Vernon Street and vitrified clay pipe between South Main Street and Vernon Street. As part of the ICM, the portion of the sewer east of South Main Street was removed as well as approximately 2 feet of soil around the outside of the sewer. Approximately 15,000 cubic yards of soil was removed from the ICM excavation area (which encompassed approximately 4.75 acres of land). The average excavation depths ranged from 0.5 to 7 feet below grade. Excavated soil was placed in the ESI Fill Area except for 1) approximately 110 cubic yards of soil

removed from the top 6 to 12 inches along the invert and sideways of the stone sluiceway section of the former outfall sewer; and 2) approximately 50 cubic yards of soil that contained VOCs (i.e., xylene) unrelated to operations at the FMC Plant Site. The soil from the stone sluiceway excavation and the VOC-impacted soil were disposed at permitted off-Site landfill facilities.

The ICM excavation areas were backfilled with clean imported soil, and the properties were restored to the satisfaction of the property owners. A buffer strip of FMC-owned property (extending from the boundary of the 10 residential properties on the east side of South Vernon Street to 10 feet east of FMC's security fence) was backfilled with clay. The restoration activities included:

- Placement of soil and sod.
- Planting of trees and other landscape plants in accordance with landscape plans agreed to by the property owner.
- Replacement of driveways and sidewalks.
- Installation/replacement of decks, fences, patios, sheds, swing sets and other property-specific items.
- Inspection, extension/repair and re-surveying of monitoring well casings (wells 1015, B-1016 and C-1017) on Property C and A-1004 and C-1005 in the ESI Fill Area).
- Replacement of the storm sewer from the east side of South Vernon Street to South Main Street and addition of lawn drains, as agreed to by the property owners and the Village of Middleport.

After completion of the backfilling activities, post-excavation soil samples were collected from the buffer strip situated on the FMC property. Soil samples were collected at 10 locations on FMC property at 0 to 3 inches below the top of the base of the excavation. The soil samples were analyzed for total arsenic.

In February 2004, the Agencies provided the owners of the residential properties and the Village of Middleport letters that stated that ICM activities were completed and that the remediated areas (except for the small area around the roots of a tree within the South Vernon Street ROW at the southwestern corner of Niagara Street and

South Vernon Street) were suitable for unrestricted residential use. Copies of the Agencies' letters to the property owners are presented in the ICM construction report.

4.11 2007 Early Actions

During a November 8, 2006 meeting that included representatives of the USEPA, NYSDEC, NYSDOH, FMC, the Village of Middleport, and other community members, FMC proposed to perform remedies (or "Early Actions") at off-site study areas concurrently with continued implementation of the RFI/CMS activities under the AOC. During the November 8, 2006 meeting, FMC proposed the performance of Early Actions in 2007 for the Wooded Parcel of the North Commercial/Industrial Area and Culvert 105 South of Mechanic Street, and described this work as consisting of excavation of soils from the Wooded Parcel, replacement of the Culvert 105 sewer inlet pipe section on the Wooded Parcel, installation of sewer pipe in the open ditch section of Culvert 105 at Margaret Droman Park, removal of sediments from manholes in Culvert 105 south of Mechanic Street, and placement of excavated soil/debris (determined to be a nonhazardous waste) in the ESI Fill Area at the FMC Facility. During the November 8, 2006 meeting, FMC also proposed to scope and implement Early Actions with input from local officials, the community, affected property owners, and adjacent neighbors. In response, the Middleport Community Input Group (CIG) was established by the Village of Middleport officials to provide early input on proposed Early Action remedial activities. The CIG is comprised of Village of Middleport and Town of Royalton officials, the Middleport Remediation Advisory Group, the FMC Community Advisory Panel, and affected property owners. The first CIG meeting was held on November 30, 2006, and subsequent CIG meetings have been held monthly thereafter. Potential remedial alternatives for the Wooded Parcel of the North Commercial/Industrial Area and for Culvert 105 south of Mechanic Street were discussed with the CIG, affected property owners and the adjacent residential neighbors during the CIG meetings, individual meetings and/or telephone conversations. Input from the stakeholders was considered during development of the 2007 Early Action scope of work.

FMC and the Agencies discussed the scope of work and the work plan for the 2007 Early Actions from January 2007 through August 2007. As part of those discussions, FMC also proposed additional 2007 Early Actions for Culvert 105 between Sleeper and Mechanic Streets and for 13 residential properties (collectively, P-Block Properties or P-Block) along the south side of Park Avenue and between Maple Avenue and Alfred Street in the Village of Middleport, New York.

The 2007 Early Actions, which were approved by the Agencies under the ICM provisions in the AOC, were implemented in the second half of 2007. The remedial activities for each work area included the following:

2007 Early Action Work Area	Remedial Activity
Wooded Parcel	• Characterization, removal and disposition of remnants and debris relative to burned down building. • Excavation of a minimum 2 feet of material from the entire area. • Excavation of an additional 2 feet of material (i.e., for a total excavation depth of approximately 4 feet) from an approximately 20-foot wide strip along the eastern (approximately 200 linear feet) and southern (approximately 600 linear feet) property lines. • Installation of a minimum 2-foot-thick soil cover system. • Extension of the North Ditch by approximately 270 feet along the southern boundary of the Wooded Parcel, including installation of a geosynthetic clay liner (GCL) system. • Installation of new 24-inch diameter high-density polyethylene (HDPE) pipe to connect the North Ditch Extension to the existing Culvert 105 storm sewer system. • Restoration (loam and seed) of the Wooded Parcel. • Development and implementation of property use restrictions (in process) • Development and implementation of a Site Management Plan (in process)
P-Block Properties	• Excavation of 3 inches to 24 inches of surface soils from 10 residential properties on the south side of Park Avenue according to the property-specific work scopes. • Restoration of the 10 properties.
Culvert 105 Storm Sewer System South of Sleeper Street	• Line flushing and sediment removal from the buried pipe portions and catch basins/manholes of Culvert 105 South of Sleeper Street. • Excavation of impacted soils within and adjacent to open ditch sections of the Culvert 105 storm sewer system north of the canal and south of Sleeper Street, namely within Margaret Droman Park,

2007 Early Action Work Area	Remedial Activity
	three privately-owned properties adjacent to Mechanic and North Vernon Streets, and three privately-owned and one Village-owned properties adjacent to Sleeper Street. • Installation of approximately 950 linear feet of new buried pipe to replace the open ditch sections of the Culvert 105 storm sewer system, including installation of one pre-cast concrete transition box, eight pre-cast concrete manholes and nine PVC drain basins. • Restoration of these properties. • Development and implementation of a Monitoring and Maintenance Plan for accumulated sediment in sediment chamber MH-N9 at Margaret Droman Park (in process)
ESI Fill Area	• Excavated soil was placed in the ESI Fill Area.

The following Early Action activities could not be completed in 2007:

- FMC was not able to obtain access agreements from the property owners of P-Block properties P-10, P-11, and P-12 in 2007. As of February 2007, FMC has obtained access permission to property P-11 and will continue to work towards access to property P-12. The owner of property P-10 has refused to grant access permission after several requests by FMC and the Agencies.

- Remedial activities were not completed within a 24-foot radius protective root zone around a tree that is located on P-Block Property P-10 at the northern edge of the Wooded Parcel. This tree subsequently fell over during a wind storm in January 2008.

FMC intends to complete the remaining Early Actions on P-Block property P-11 and P-12 (if access permission can be obtained) and within the unexcavated P-10 protective root zone on the Wooded Parcel during the 2008 construction season.

5. Regional Setting

5.1 Demographics

The Site is located in the southeastern quadrant of the Village of Middleport. The Village of Middleport is located in the Towns of Royalton and Hartland at the eastern boundary of Niagara County. According to the 1990 census, the populations of Niagara County and the Village of Middleport are 220,756 and 1,874, respectively. The populations of both areas decreased between 1980 and 1990 (Niagara County 3% and Middleport 6%). The current population of the village is 1,917 (based on the 2000 census).

The Roy-Hart School District had approximately 1,650 students enrolled during the 2004-2005 school year. The Roy-Hart High School and Middle Schools are located on school property situated along the northern boundary of the FMC-owned North Railroad Property. The Middle School has approximately 364 students (grades 5 through 7) and the High School has approximately 834 students (grades 7 through 12). The Roy-Hart elementary school (grades K through 6) is located in Gasport, New York (approximately 6 miles west of Middleport) and has approximately 452 students.

Most of the Village of Middleport consists of residential properties. The village has a central business district and also has other business and industrial properties in the vicinity of the Site. The outer and surrounding areas are primarily agricultural. The zoning of the area surrounding the Site is shown on Figure I2.5.

The study areas north of Pearson Road and East of Stone Road (i.e., downstream portion of Tributary One, and segments of Jeddo and Johnson Creeks) are situated in rural farming areas within the Towns of Hartland, Ridgeway and Yates. The zoning along Tributary One north of Pearson Road and West of Stone Road, Jeddo Creek (north of Route 104) and Johnson Creek (the section within Orleans County) areas is shown on Figure I2.7.

5.2 Physiography

Middleport lies within the Niagara Region of the Erie-Ontario Plain. The Erie-Ontario Plain is bordered to the south by the exposed crest of the Niagara Escarpment. Resistant dolostone beds of the Lockport Group form the Escarpment crest. The elevation of the top of the Niagara Escarpment is approximately 600 feet above mean

sea level (AMSL), and the face slopes gently to the north to an elevation of approximately 500 feet AMSL at the Village of Middleport. The ground surface continues to slope in a northerly direction from the base of the escarpment to the glacial Lake Iroquois shoreline. The topographic features of the area within a 4-mile radius of the Site are shown on Figure I2.17.

5.3 Climate

The climate of the Middleport area is classified as humid continental, consisting of cool-wet winters and hot-wet summers. The mean monthly temperature and precipitation data generated at the Lockport meteorological station, which is approximately 10 miles west of the Site, are presented in Table 5.1.

The mean annual temperature is 47.8°F, with the coldest average temperature occurring in January (23.6°F) and the warmest in July (70.9°F). Mean daily temperatures below 32°F occur from mid November through mid April. It is estimated that the average frozen ground days occur from mid December through early March, which is approximately 85 days per year.

The mean monthly precipitation ranges from 2.2 to 3.9 inches. The annual total mean precipitation is approximately 37 inches. Precipitation events of greater than 0.01 inch (rainfall equivalent) occur on an average of 10 to 16 days per month (153 days/year). Approximately 41 of the 153 days per year with precipitation events are estimated to occur on frozen ground days.

The prevailing wind direction in the Middleport area is southwest to northeast. A wind rose from the Niagara Falls weather station is presented on Figure I5.1. The wind rose plot based on Niagara Falls 1982-1986 meteorological data is used based on the Agencies' preference expressed in a letter dated May 6, 1996 (Agencies 1996c).

5.4 Regional Geology

5.4.1 Overburden

The overburden materials in northern Niagara County reflect the advancement of the Wisconsinian ice sheet; the last advancement in a series of glaciations during the Pleistocene Epoch which terminated approximately 10,000 years before present. These overburden materials consist primarily of:

- End moraine deposits.
- Ground moraine deposits (till) of the Wisconsinian (Muller 1977).

Regional end moraine deposits occur throughout the region as a narrow band of loosely consolidated sand, silt and gravel north of the Middleport Site along present day State Route 104. This end moraine also defines the former southern shoreline and beach-ridge of ancestral Lake Iroquois. North of Route 104, surficial materials consist of thick sequences (10-30 feet) of silt and clay deposited within Lake Iroquois, which was in contact with the receding Wisconsinian ice sheet. Glacial sediments south of Route 104 reflect deposition directly below the ice sheet, and generally consist of lodgment and ablation tills. These sediments are typically a series of unsorted, heterogeneous materials consisting of clay, silt, sand, gravel and cobbles. Grain size in the till materials varies spatially from a silty-clay to sandy-silt throughout the area. The thickness of till materials varies between approximately 5 to 20 feet, with total thickness generally decreasing southward to the Niagara Escarpment.

The overburden, due to its high clay content, is relatively impermeable in the Middleport area. The limited groundwater flow within the overburden is in a downward direction.

5.4.2 Bedrock

The bedrock in northern Niagara County consists of a thick sequence of Ordovician-Silurian clastic and carbonate rocks of the Richmond, Medina, Clinton and Lockport Groups deposited within the Appalachian Foreland Basin. A detailed description of individual formations is provided on Figure I5.2. Regionally, this bedrock sequence forms the Niagara Escarpment, a low relief ridge which outcrops south of the Middleport Site. The Escarpment is capped by the resistant Lockport Dolomite, below which a sequence of limestone, shale, and sandstone subcrop to the north. These subcrop belts trend generally east-west, sub-parallel to the south shore of Lake Ontario (Figure I5.3). Figures depicting the location of a stratigraphic cross section and a schematic of the cross-section through the Site are provided as Figure I5.4 and Figure I5.5, respectively.

The lower-most, and oldest stratigraphic unit encountered in the area is the Upper Ordovician Queenston Formation (shale), which is generally 700 to 800 feet in thickness, extending beneath Lake Ontario. An unconformity exists as the boundary between the Queenston Shale and overlying Whirlpool Sandstone (Lower Silurian age, Medina Group).

5.4.3 Regional Structural Geology

The Niagara Region exhibits the structural signatures of both Paleozoic Appalachian Basin tectonics and more recent (Neocene) tectonics reflecting isostatic rebound subsequent to Pleistocene glacial recession. Structural features noted to occur in the region include gentle folds, monoclines and vertical bedrock joints. The dominant regional bedrock joint set is oriented northeast (60 degrees). Characteristically, the bedrock in the region exhibits a gentle (less than two degrees) southward dip.

5.5 Regional Hydrogeology

Overburden groundwater flow in the Middleport area is controlled by the fine grained nature of sediments. Groundwater flow rates within the overburden vary considerably between the lower permeability sediments, and where silt and sand lenses occur within the till unit. Vertical recharge from overburden to fractured bedrock is likewise controlled by the permeability of the till. Depths to groundwater are typically less than 15 feet in the overburden materials.

Regional bedrock groundwater flow is controlled by secondary porosity of the bedrock, including vertical joints, fractures and bedding plane partings. Horizontal and vertical fracture frequency increases near the Niagara Escarpment edge, and transmits groundwater to underlying bedrock formations and overburden, often discharging as seeps and springs along the Escarpment edge. The hydraulic conductivity of bedrock formations is widely variable, and is controlled by the secondary porosity of the rock matrix. Hydraulic conductivity varies by several orders of magnitude within individual formations. A generally downward hydraulic gradient exists throughout the region; however, slightly upward gradients have been identified within deeper units along the Escarpment, including the Queenston Shale and lower units of the Medina Group. North of the Escarpment, bedrock groundwater flows northward eventually discharging to lower bedrock strata, to streams which have incised through the overburden into bedrock and to Lake Ontario.

Due to its thickness (approximately 800 feet) and its low permeability, the Queenston Formation is considered the base of the regional groundwater flow system. Groundwater flow within the Queenston Formation occurs principally within the fractured and weathered zone (typically less than 5 feet thick) at the top of the shale. Below the weathered top of the Queenston Formation, groundwater is characterized by significantly higher total dissolved solids and chloride, suggesting little recharge to or flushing of the formation.

5.6 Groundwater Usage

Groundwater is not extensively utilized in the Middleport area due to the limited water bearing characteristics of the underlying strata and poor water quality due to natural bedrock conditions. Bedrock groundwater quality is dominated by sulfate and calcium in the more shallow formations such as the Lockport Group and is dominated by elevated total dissolved solids and brackish sodium-chloride brines in deeper bedrock flow systems of the Clinton and Richmond Groups. This evolutionary trend is typical of downward-migrating groundwater in sedimentary basins (Novakowski and Lapcevic 1988).

Properties in the Village of Middleport receive potable water from the Niagara County water supply system. Village residents are required by ordinance to be connected to this system in accordance with personal communications with Daniel Seaman, Esq., lawyer for the Village of Middleport (Seaman 1997). The Village currently receives 100% of its water from the Niagara County Water District (since July 2001). According to village personnel, the average water consumption rate for the village is 310,000 to 320,000 gallons per day.

Prior to July 2001, the Village supplemented 0 to 20% of its water supply from the Village municipal well (private well number 1) during periods when the regional water table is high. The Village municipal well is located hydraulically upgradient of the Site. The well was installed in 1916 and is completed in the Lockport Group. It is approximately 65 feet in diameter, 17 feet deep, and is spring-fed. The maximum water supply provided by this well was approximately 100,000 gallons per day.

As discussed in Section 3.3.2, FMC performed several private water well inventories and studies in 1985 through 1987, 1990, and 2000 through 2002, and identified 128 wells located within a one-mile radius of the Site (see Figure I3.4).

6. Middleport Area Soil Background Studies

Arsenic is a naturally occurring element that is present in soil as a result of both geologic background and contamination through anthropogenic uses including, pesticide applications, fertilizers, wood treatment, and various industrial and manufacturing uses. Arsenic presence within the FMC off-Site study areas can be attributable to natural conditions and to both FMC and non-FMC anthropogenic sources. The areas within and around Middleport have historically included farm fields and orchards. In an attempt to estimate the approximate extent of arsenic presence in soil that may be potentially related to past operations at the FMC Facility, a thorough understanding of the background levels of arsenic (from natural and non-FMC related anthropogenic sources) in soil within the Middleport study areas is required.

Since the mid-1980s, FMC and/or the Agencies variously performed soil sampling and analysis and/or background data evaluations as part of several studies to characterize local background arsenic concentrations (attributable to natural and non-FMC related anthropogenic sources) in Middleport area soils. These studies included:

November 1985 Roy-Hart School Surface Soil Sampling & Analysis Program – Conducted by FMC that included the collection and arsenic analysis of surface soil samples from the Roy-Hart Elementary School in Gasport.

January 1989 NYSDOH Soil Sampling Program in Middleport, New York – Included the collection and arsenic analysis of surface soil samples from residential yards north of the Facility between the North Railroad Property and State Street, along Tributary One south of the Canal, and farm fields approximately 1,200 to 3,500 feet east of the FMC facility.

1989 Gasport Orchard Study – FMC collected soil samples from an active apple orchard east of Gasport in 1989 to further characterize background arsenic and lead concentrations in orchards (CRA 1989e).

1990-1993 Off-Site Investigation – Included the collection and analysis of surface soil samples by FMC to characterize background soils south, southeast and east of the FMC facility, and in Gasport (CRA 1993c).

1999 Draft RFI Report – In early 1996, the Agencies identified a set of arsenic soil background data from 11 background locations sampled as part of the above-mentioned studies and in early 1997 they indicated that, in the case of arsenic, FMC may utilize background soil concentration data in conjunction with EPA guidance, for comparisons to FMC Middleport site data (Agencies 1997a). FMC's 1999 draft RFI Report (CRA 1999a) identified 30 mg/kg (the 95 percent Upper Confidence Level (UCL) on the arithmetic mean of the arsenic background data set) as an appropriate criterion for comparison to investigative data. This value was used in the draft 1997 RFI Report and in the revised draft 1999 RFI Report. References to the specific letters from the Agencies are included in those RFI Reports and in the references in Part 7 of this Report.

2001-2003 Gasport Area Background Study – In mid 2000, the Agencies proposed a program to re-evaluate local arsenic background concentrations in Middleport soils with collection of a larger, more extensive data set. This program, which is described in Part A – Work Plan for Development of Arsenic Background in Middleport Soil (Agencies, 2001), included the collection and analysis of surface soil samples from the Gasport Area. FMC implemented the Agencies' work plan beginning in December 2001, issued a final report (Development of Arsenic Background in Middleport Soils [CRA 2003a]) in February 2003, and submitted revisions in May 2003. The Agencies approved the report (see Appendix 6A) in June 2003. The study included collection and arsenic analysis of surface soil samples from orchards, agricultural fields, undeveloped wooded properties, public properties and residential properties in Gasport. The arsenic data from the study was used to calculate various arsenic soil background criteria for Middleport.

In June 2007, FMC submitted a report entitled Background Arsenic Soil Concentrations in Middleport, New York (Gradient Corporation 2007) (June 2007 Background Report) that summarizes the soil arsenic background data collected through 2003 in Middleport and Gasport. The June 2007 Background Report (see Appendix 6A) also includes information about soil arsenic background collected in the neighboring community of Lyndonville, nine miles northeast of Middleport.

The June 2007 Background Report presented recalculated soil arsenic background statistical values. The background values were recalculated in accordance with the methods that the Agencies developed and approved for the 2001-2003 Gasport study using new information that became available in late 2004. That new information consisted of additional aerial photos of the Middleport Study Area that showed significantly more historic orchard presence than had been previously

estimated and used in the 2001-2003 Background Study. The Agencies provided FMC comments on the June 2007 Background Report and the re-calculation of the background values (using the new information of historic orchard presence in Middleport) during meetings held on December 11, 2007 and on February 14, 2008 and in a letter to FMC dated March 10, 2008.

The Agencies' March 10, 2008 letter determined that the appropriate criterion for delineation of FMC-related arsenic in the Middleport area soil shall be 20 ppm (based on the weighted 95th Percentile of the 2001-2003 Gasport Arsenic Background Data Set), with consideration given to other factors (e.g., data variability, flood zone topography, wind patterns, ground features, site-specific historic land use, etc.) that would influence air deposition. FMC responded to the Agencies' March 10, 2008 letter by letter dated March 28, 2008, and agreed to the Agencies' directive to use 20 ppm in combination with other factors to delineate potential FMC-related soil arsenic in RFI Report Volumes II, IV and V (described in Section 1.1).

FMC's letter dated March 28, 2008 also stated that information concerning the new aerial photos, revised historic land use percentages/weighting factors, and associated statistical values (including the weighted 95th and 98th percentiles) would be included in the appropriate RFI Report and CMS Report volumes. The land use weighting factors and associated statistical values would be estimated using both the method discussed during the February 14th meeting (e.g., use of two time periods, as described in the approved September 2001 Work Plan for Development of Arsenic Background in Middleport Soil) and the Agencies' method set forth in the March 10, 2008 letter, which uses time-weights for each photo date. Appendix 6B presents the aerial photos used to identify the historic land usages in the Middleport study area and the revised land use weighting factors and associated statistical values estimated using both the 2001 Work Plan method and the Agencies' method.

7. References

Agencies. 1995a. Letter to Mr. James Bodamer, FMC Corporation, from Mr. Andrew Bellina, USEPA, and Ms. Denise Radtke, NYSDEC. Agencies provide comments on RFI Summary Report and request installation and sampling of additional off-Site groundwater monitoring wells and collection and analysis of additional on- and off-Site soil samples. April 12, 1995.

Agencies. 1995b. Letter to Mr. James Bodamer, FMC Corporation, from Mr. Andrew Bellina, USEPA, and Ms. Denise Radtke, NYSDEC. Agencies provided comments on FMC's March 3, 1995 responses to the Agencies' comments on FMC's Groundwater Assessment Report and a summary of the approved modification to the Groundwater Monitoring Program. April 25, 1995.

Agencies. 1996a. Letter to Mr. James Bodamer, FMC Corporation, from Ms. Denise Radtke, NYSDEC, and Mr. Andrew Bellina, USEPA. The Agencies presented their final determinations with respect to the need for additional soil sampling and on FMC's July 19, 1995 proposed scope of work for additional soil sampling and analysis as part of the RCRA Facility Investigation. January 24, 1996.

Agencies. 1996b. Letter to Mr. James Bodamer, FMC Corporation, from Ms. Denise Radtke, NYSDEC, and Mr. Andrew Bellina, USEPA. The Agencies clarified issues concerning remaining soil sampling issues noted in the July 12, 1995 Notice of Dispute with respect to the RCRA Facility Investigation. March 7, 1996.

Agencies. 1996c. Letter to Mr. James Bodamer, FMC Corporation, from Ms. Denise Radtke, NYSDEC, and Mr. Andrew Bellina, USEPA. Presents comments to FMC's February 14 and March 22, 1996 submittals which included responses to Agencies' comments on additional RFI soil sampling, a Deposition Model Study, and a statistical approach for development of the arsenic soil background screening criterion and arsenic data comparison. May 6, 1996.

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