US Army Corps
of Engineers®
Buffalo District

PROPOSED PLAN

FOR THE GROUNDWATER OPERABLE UNIT

LINDE SITE, TONAWANDA, NEW YORK

MARCH 2006

UNITED STATES ARMY CORPS OF ENGINEERS
PROPOSED PLAN FOR THE GROUNDWATER OPERABLE UNIT, LINDE SITE
TONAWANDA, NEW YORK

A Proposed Plan for the Tonawanda Site in Tonawanda, New York was prepared by the United States Department of Energy (DOE) in September 1993 under its authority to conduct the Formerly Utilized Sites Remedial Action Program (FUSRAP). The 1993 Proposed Plan for the Tonawanda Site addressed remediation of radioactive contamination at the four (4) locations in the Town of Tonawanda that comprised the Tonawanda Site as defined at that time: the Linde (now Praxair) Site; the Ashland 1 Site; the Ashland 2 Site; and the Seaway Site.

On October 13, 1997, the Energy and Water Development Appropriations Act, 1998 was signed into law as Public Law 105-62. Pursuant to this law, FUSRAP was transferred from the DOE to the United States Army Corps of Engineers (USACE). As a result of this transfer the responsibility for this project was transferred to USACE. The Energy and Water Development Appropriations Act for Fiscal Year 2000, Public Law 106-60, provides authority to USACE to conduct restoration work on FUSRAP Sites subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 United States Code 9601 et seq., as amended. This USACE authority is limited to remediating contamination related to the nation's early atomic energy program. Other contamination is not eligible under FUSRAP. Therefore, this Proposed Plan will only address FUSRAP eligible constituents of concern.

USACE reviewed the response action recommended in the 1993 Proposed Plan (DOE 1993), supplemental information contained in the Addendum to the Feasibility Study for the Linde Site (USACE 1999a), other relevant documents, and the records of public meetings conducted following preparation of the 1993 Proposed Plan and issued a Proposed Plan for the Linde Site in March 1999 (USACE 1999b). After considering the comments on the March 1999 Proposed Plan, USACE issued a CERCLA Record of Decision (ROD) for the Linde Site in March 2000 (USACE 2000). The March 2000 ROD for the Linde Site outlines remedial actions to be undertaken to address soils and structures that are radioactively contaminated as a result of uranium processing at Linde in the 1940s under a Manhattan Engineer District (MED)/Atomic Energy Commission (AEC) contract. The March 2000 ROD excludes CERCLA decision-making on Building 14 and groundwater at the Linde Site. This Proposed Plan addresses the Groundwater Operable Unit (OU) at the Linde Site and was prepared to fulfill the requirements of CERCLA Section 117(a) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [40 CFR 300.343(f)(2)]. Building 14 was remediated by USACE in accordance with the April 2003 USACE ROD (USACE 2003a) for the Building 14 OU at Linde.

USACE reviewed the March 2000 Record of Decision (USACE 2000) for the Linde Site, the Feasibility Study report (USACE 2004) and the Addendum to the Feasibility Study report (USACE 2005)for the Groundwater OU at the Linde Site, and other relevant documents and has concluded that no completed pathways exist for current or future exposure to FUSRAP eligible constituents of concern in Linde groundwater. The groundwater operable unit at the Linde Site poses no current or future threat to human health or the environment and, therefore, no CERLCA action is warranted.

USACE invites members of the public to review the Proposed Plan and the supporting documents, which further describe the Groundwater OU at the Linde Site, and are the basis for this Proposed Plan. These documents may be found in the administrative record files for the Tonawanda Sites or the Linde Site at the USACE Public Information Center, 1776 Niagara Street, Buffalo, NY 14207 or the Tonawanda Public Library, 333 Main Street, Tonawanda, NY 14150.

Members of the public who wish to comment on this proposed plan may submit their comments in writing to USACE at the following address:

U.S. Army Corps of Engineers
Buffalo District
FUSRAP Information Center
1776 Niagara Street
Buffalo, NY 14207-3199

Please refer to this Proposed Plan or to the Groundwater OU, Linde Site, in any comments. All comments will be reviewed and considered by USACE in making its final decision on any actions to be conducted at the Groundwater OU, Linde Site. Comments should be submitted no later than 30 days after the date of this Proposed Plan.

After the close of the public comment period, USACE will review all public comments, as well as the information contained in the administrative record file for this site, and any new information developed or received during the course of this public comment period, in light of the requirements of CERCLA and the NCP. An authorized official of USACE will then make a final decision on Linde Site groundwater. This decision will be documented in a ROD, which will be issued to the public, along with a response to all comments submitted regarding this Proposed Plan.

If there are any questions regarding the comment process, or the Proposed Plan, please direct them to the address noted above, or telephone (716) 879-4438 or 1 (800) 833-6390.

for LTC

Bruce A. Berwick
Brigadier General, U.S. Army
Commanding

4.18.06

Date

UNITED STATES ARMY CORPS OF ENGINEERS
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ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
bgs	below ground surface
BNI	Bechtel National, Inc.
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Ci	Curie
cm/s	centimeters/second
COC	constituent of concern
Conrail	Consolidated Rail Corporation
CPS	counts per second
DOE	Department of Energy
FS	Feasibility Study
FSP	Field Sampling Plan
ft	foot/feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
g	gram
L	liter
lb(s)	pound(s)
MCLs	Maximum Contaminant Levels
MED	Manhattan Engineer District
m	meters
μg	microgram
μ	micron
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NRC	Nuclear Regulatory Commission
NWI	National Wetlands Inventory
NYSDEC	New York State Department of Environmental Conservation
OU	Operable Unit
pCi	picocuries
PP	Proposed Plan
ppm	parts per million
QAPP	Quality Assurance Project Plan
Ra	radium
RI	Remedial Investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SMCLs	Secondary Maximum Contaminant Levels
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Test
TDS	total dissolved solids
Th	thorium
TPP	technical project planning
U	uranium
UMTRCA	Uranium Mill Tailings Radiation Control Act
U.S.	United States
U.S.C.	United States Code
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WET	Waste Extraction Test
yr	year(s)

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1. INTRODUCTION

1.1 Status of the Tonawanda FUSRAP Sites

A Proposed Plan (PP) (DOE 1993a) for the Tonawanda Site in Tonawanda, New York was prepared by the DOE in September 1993 under its authority to conduct the FUSRAP. The 1993 PP for the Tonawanda Site addressed remediation of radioactive contamination at the four (4) locations in the Town of Tonawanda that comprised the Tonawanda Site as defined at that time: the Linde Site; the Ashland 1 Site; the Ashland 2 Site; and the Seaway Site. The regional and vicinity locations of the Tonawanda FUSRAP sites are shown in Figures 1 and 2.

At the public hearing and during the public comment period, numerous concerns and comments were raised by the community and their representatives regarding the preferred alternative described in DOE's 1993 PP, which included the disposal of remediation wastes from the Tonawanda Site properties in an on-site engineered disposal facility to be located at Ashland 1, Ashland 2, or Seaway. In 1994, DOE suspended the decision-making process on the 1993 PP and re-evaluated the alternatives that were proposed.

In October 1997, responsibility for FUSRAP was transferred to USACE. As a result of this transfer the responsibility for the Tonawanda FUSRAP sites was transferred to USACE.

A PP for the Ashland 1 (including Seaway Area D) and Ashland 2 sites, commonly referred to as the Ashland Sites, was issued by USACE in November 1997 (USACE 1997) and a ROD for the Ashland Sites was issued by USACE in April 1998 (USACE 1998). Remediation of the Ashland Sites was initiated by USACE in June 1998. The Seaway Site is being addressed in a separate CERCLA documentation. The status of the Linde Site is described below.

1.2 Linde Site Status

In March 1999, USACE issued an Addendum to the Feasibility Study (USACE 1999a) and a PP (USACE 1999b) for the Linde Site. After considering the comments on the March 1999 PP, USACE issued a CERCLA Record of Decision (ROD) for the Linde Site in March 2000 (USACE 2000). The March 2000 USACE ROD outlines remedial actions to be undertaken at Linde to address radioactively contaminated soils and structures, but excludes CERCLA decision-making on Building 14 and groundwater at the Linde Site. Remediation of FUSRAP eligible constituents of concern (COCs) in Linde Site soils and structures in accordance with the March 2000 ROD was initiated in June 2000 and is scheduled for completion in 2009.

In 1992, the DOE designated two properties, the Town of Tonawanda Landfill and the Mudflats Area, into FUSRAP as a Vicinity Property of the Linde Site due to the discovery of materials that appeared to have similar characteristics to MED/AEC materials. USACE is conducting CERCLA studies of these properties and decisions on potential FUSRAP actions will be made in the future. The locations of these properties are shown in Figure 2.

The March 2000 ROD for the Linde Site outlines the remedial actions to be undertaken on portions of the Linde Site by USACE to address soils and structures determined to be radioactively contaminated as a result of uranium processing operations conducted at Linde in the 1940s under an MED/AEC contract.

The March 2000 ROD excludes CERCLA decision-making on Building 14 and Site groundwater. Specifically, the March 2000 ROD states, in part, that "the remedy selected...[in the ROD]...does not include Building 14 nor the soils beneath Building 14" and "the final remediation of Building 14 and soils under Building 14 has been excluded from this [March 2000] ROD, to be addressed separately in the future."

The March 2000 ROD, page iii, states "This ROD also does not address the groundwater at the Linde Site. A ROD will be issued in the future that evaluates the Site groundwater and selects any required remedial action" (USACE 2000). Concerning groundwater, the March 2000 USACE ROD for the Linde Site states, in part, that the original proposed plan for the Linde (Tonawanda) site(s) [by DOE in 1993] proposed that no action was warranted to address on-site groundwater, that USACE further investigated existing information relating to groundwater, and that USACE also concluded that no remediation of groundwater is warranted.[1] The March 2000 ROD for the Linde Site further notes, page 38, however, that "comments received during the comment period expressed concerns about the sufficiency of the samples relied upon in coming to conclusion that no remediation of the groundwater is warranted."

Linde Building 14 and Linde groundwater are referred to, respectively, as the Building 14 Operable Unit (OU) and the Groundwater OU at the Linde Site.[2] The Building 14 OU at Linde was remediated by USACE in accordance with a ROD for the Building 14 OU issued by USACE in April 2003 (USACE 2003a). This PP addresses the Groundwater OU at Linde.

The shallow and the deep groundwater comprise the Groundwater OU at Linde. As described in detail in Section 3, the shallow groundwater at Linde is separated from the deep groundwater by a thick layer of clay. Extensive remediation of FUSRAP eligible contaminants in site soils and buildings (Section 2.4) has removed potential sources of contamination of shallow groundwater. As described in Section 4.4.2 and 4.5.2, USACE has determined that no further action is warranted for the shallow groundwater at Linde since potential sources of contamination have been removed. As described in greater detail in Section 3.3, liquid wastes from MED/AEC-related operations were injected into the deep groundwater at Linde in the early to mid-1940s. Extensive investigations of deep groundwater have been conducted at Linde, including prior investigations by the DOE and the more recent USACE investigations described in Section 4. As described in the following sections, USACE has also determined that no action is warranted for deep groundwater at the Linde Site. In determining that no action is warranted for shallow or deep groundwater at the Linde Site, USACE addressed only the groundwater impacted by releases

[1] The 1993 RI report for the Tonawanda Site (BNI 1993) addresses the Linde, Ashland 1, Ashland 2, and Seaway FUSRAP sites in Tonawanda and notes (page 3-61) that in the Linde area, water drawn from the Camillus Shale (the deep groundwater) has high levels of total dissolved solids and salinity that preclude its use for drinking purposes without extensive, costly treatment. In assessing potential pathways for exposure to radionuclides at the Tonawanda Site, the 1993 BRA report (DOE 1993a) concludes (in Section 3.3.4) that a completed groundwater exposure pathway does not exist because groundwater is not potable. The 1993 FS report (DOE 1993b) concluded (page ES-4) that groundwater at the Tonawanda Site was not significantly impacted by MED-related activities, was not currently or projected to be used as a drinking water source, and remediation of site groundwater was not considered necessary. These documents and the references cited in these documents were reviewed by USACE is concluding, in the March 2000 ROD, that no remediation of groundwater was warranted. As further described in this Proposed Plan, additional investigations conducted by USACE at Linde in 2001 and 2002 further confirmed this conclusion.

[2] The NCP defines an operable unit to mean "a discrete action that comprises an incremental step toward comprehensively addressing site problems. This discrete portion of a remedial response manages migration, or eliminates or mitigates a release, threat of release, or pathway of exposure. The cleanup of the site can be divided into a number of operable units, depending on the complexity of the problems associated with the site. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action, or may consist of any set of actions performed over time or any actions that are concurrent but located in different parts of a site (40 CFR 300.5)."

from the early site operations related to the MED-AEC programs. This is the final decision regarding any FUSRAP response action for the FUSRAP Groundwater OU.

1.3 Groundwater Investigations Conducted by USACE at Linde in 2001 and 2002

In March 2000, USACE conducted Technical Project Planning (TPP) meetings with representatives of the New York State Department of Environmental Conservation (NYSDEC), the United States Environmental Protection Agency (USEPA), and other interested parties to develop plans for any supplemental investigations of potential MED-related groundwater contamination at Linde. At the meeting conducted on March 28, 2000 involving NYSDEC, USEPA and USACE, it was agreed that the available geologic and hydrogeologic information was adequate for site characterization, but it was also agreed that additional information was required to address several issues concerning groundwater contamination.

A detailed plan for acquiring the additional information required was subsequently developed, with review by interested parties and USACE approval. The details of the objectives and scope of the additional investigation, including specific field activities, are provided in the January 26, 2001 *Sampling and Analysis Plan – Volume I – Field Sampling Plan (FSP) and Volume II – Quality Assurance Project Plan (QAPP), Linde Groundwater Operable Unit* (USACE 2001). Details of the TPP deliberations and concurrences by NYSDEC and USEPA are provided in the FSP. USACE conducted the field investigations in accordance with the FSP beginning in January 2001. The results of the USACE 2001 investigation of groundwater at the Linde Site are described in the January 2002 report *Results of the 2001 Groundwater Investigation at the Linde Site, Tonawanda, New York* (USACE 2002a).

In May 2002, representatives of NYSDEC and USACE met to discuss NYSDEC comments on USACE's January 2002 report and NYSDEC recommendations for further sampling. It was agreed that additional groundwater sampling and soil sampling for additional leaching tests would be conducted. A June 2002 document, *Sampling and Analysis Plan Addendum* (SAP Addendum) *Linde Groundwater Operable Unit, Tonawanda, New York* (USACE 2002b), developed by USACE describes the scope of the additional investigation. Additional investigations were conducted in accordance with the SAP Addendum in August 2002. The results of the 2001 and 2002 investigations are provided in the report, *Results of the 2001 and 2002 Groundwater Investigations at the Linde Site, Tonawanda, New York* (USACE 2003b).

1.4 Overview of this Proposed Plan

This plan provides background information on the Linde Site, shallow Linde groundwater and deep groundwater in the area of the underground injection wells used during the MED/AEC era. It summarizes the findings and conclusions of USACE groundwater investigations conducted at the Linde Site to address the significance of FUSRAP eligible COCs in Linde groundwater, presents the rationale for USACE recommendations for Linde groundwater, summarizes investigations conducted by USACE, and outlines the public's role in helping USACE make a final decision on Linde groundwater.

The key documents used in the preparation of this PP are:

- *Remedial Investigation [RI] Report for the Tonawanda Site* (BNI 1993). The RI report was prepared in 1993 for DOE and reflects the findings of investigations conducted at Linde and other Tonawanda Site properties through 1992. Extensive information on soils contamination, geology, and hydrogeology at Linde is provided in the RI report. The historical information on discharge of MED waste effluent to deep groundwater at Linde in the 1940's is also provided. Results of analyses of groundwater samples from the deep wells at Linde that were constructed during the RI are also provided.

- *Synopsis of Historical Information on Linde Effluent Injection Wells* (USACE 1999c). This document is a review and reassessment of existing information concerning the effects on deep groundwater quality resulting from the injection of process wastes to the subsurface during uranium processing conducted at Linde from 1943 to 1946. This document concludes, as also concluded in the 1993 Proposed Plan, that groundwater remediation at Linde is not required.

- *Record of Decision for the Linde Site, Tonawanda, New York* (USACE 2000). The ROD for the Linde Site provides a description of the Linde Site, Linde Site contaminants, remedial action cleanup objectives, a description of remedial action alternatives, an evaluation of remedial action alternatives, and the remedial action selected for the Linde Site, excluding Building 14 and groundwater.

- *Feasibility Study Report for the Groundwater Operable Unit, Linde Site, Tonawanda, New York* (USACE 2004). The October 2004 Feasibility Study (FS) report was prepared to serve as a principal source of information for CERCLA decision-making on the Groundwater OU at the Linde Site. Consistent with the ROD for the Linde Site, the FS report focuses on Linde Groundwater and supplements the information presented in the FS for the Tonawanda Site (DOE 1993b) prepared by DOE in 1993 and the Addendum to the FS for the Linde Site (USACE 1999a) prepared by USACE in 1999. Descriptions of the Linde Site, history and the circumstances leading to Linde groundwater contamination are presented. The results of investigations conducted at Linde in the past to determine the nature and extent of groundwater contamination of Linde groundwater are summarized. Findings of groundwater investigations conducted by USACE in 2001 and 2002 are described. Significant sections of the October 2004 FS report have now been superseded by the September 2005 Addendum to the FS report described below.

- *Addendum to the Feasibility Study Report for the Groundwater Operable Unit, Linde Site, Tonawanda, New York* (USACE 2005). The September 2005 Addendum to the FS report was prepared to document a further assessment to determine the potential for exposure scenarios under which exposures to FUSRAP eligible COCs in groundwater might occur. Based on the additional assessment, USACE concluded that no completed pathways exist for current or future exposure to FUSRAP eligible COCs in Linde groundwater and, therefore, no action is warranted for deep or shallow groundwater at the Linde Site. The Addendum to the FS presents these findings and documents the associated revisions to the October 2004 FS report.

This PP summarizes information that can be found in greater detail in the reports mentioned above and in other documents contained in the administrative record file for the Tonawanda Sites or the Linde Site which can be found at the USACE Public Information Center, 1776 Niagara Street, Buffalo, NY 14207 or the Tonawanda Public Library, 333 Main Street, Tonawanda, NY 14150. USACE encourages the public to review these documents.

The final decision on Linde groundwater will be documented in the ROD for the Groundwater OU at the Linde Site only after consideration of all comments received and any new information presented. USACE may modify this proposed plan based on new information or public and/or regulatory agency comments. Therefore, the public is encouraged to review and comment on this proposed plan.

2. SITE BACKGROUND

2.1 Linde Site Overview

The Linde Site is now owned by Praxair, Inc. and comprises about 135 acres located at East Park Drive and Woodward Avenue in the Town of Tonawanda. The site is bounded on the north and south by other industrial properties and small businesses, on the east by CSX Corporation (CSX) [formerly Consolidated Rail Corporation (Conrail)] railroad tracks and Niagara Mohawk property and easements, and on the west, by a park owned by Praxair, which is open to the public. West of the park owned by Praxair, the Site is bounded by a low density residential area and a school. The regional and vicinity locations of the Linde Site are shown in Figures 1 and 2.

The property contains office buildings, fabrication facilities, warehouse storage areas, material laydown areas, and parking lots. Access to the property is controlled by Praxair. Approximately 1,400 employees work at the Praxair facilities. Figure 3 shows Linde Site locations.

The property is underlain by a series of utility tunnels that interconnect some of the main buildings and by an extensive network of storm and sanitary sewers. The Linde Site is served by public water and sanitary sewer systems. The source of the public water supply is the Niagara River, which has a flow in excess of 100 billion gallons per day. Groundwater at the Site is not currently utilized for any purpose and because an ample supply of fresh water is available from the public water supply system, no future use of Linde Site groundwater is anticipated. Development of the deep groundwater at Linde as a source of drinking water is precluded without costly treatment to remove naturally occurring high levels of total dissolved solids and other constituents. Development of the shallow groundwater at Linde is precluded due to unsuitable subsurface conditions. In the event that a water supply well was to be installed and used at the Site, a building and/or plumbing permit would be required under Chapter 54 of the Town Code. While there are no specific prohibitions against such facilities, Town approval would be required. The Erie County Department of Health would have to approve any public water supply well.

The Linde property is generally flat and it is estimated that approximately half of the Linde plant area is covered with impervious surfaces such as roofs, paved areas and sidewalks; the other half is covered with a packed gravel surface and sod that allows infiltration of precipitation. Several railroad spurs extend onto the property from the CSX property east of the site.

Land uses in proximity to the Linde property include the CSX property, commercial and residential areas to the east, small businesses, light industries, and residential areas to the north, business and industrial areas to the south, and a low density residential area and Holmes Elementary School to the west. Sheridan Park, owned by the Town of Tonawanda's Parks and Recreation Department, is located one-fourth mile to the northwest of the Linde property. Twomile Creek flows through this property. Recreational uses include an 18-hole public golf course, picnicking, and playgrounds. Other uses within one mile of the Linde property include five schools, two community buildings, a senior citizens' center, and Kenmore Sisters of Mercy Hospital. The Linde property is fenced and has a buffer zone of grass and trees around the main buildings (DOE 1993a).

2.2 Zoning and Future Land Uses

The Linde Site is currently used for commercial and industrial purposes, and industrial facilities have been present at the site for more than 60 years. As described above, the site is surrounded by industries and small businesses on three sides and on the fourth side a park owned by Praxair.

The Town of Tonawanda has adopted a zoning ordinance that regulates land uses in the Town and zoning districts were established to permit varying degrees of land uses. The Linde property is located in a Performance Standards Zoning District. The purpose of the Performance Standards District is to encourage and allow the most appropriate use of the land available now as well as approaching future commercial and industrial uses unhampered by restrictive categorizing, thus extending the desirability of flexible zoning.

Restrictions in this district permit an institution for human care or treatment or a dwelling unit only if the development abuts a residential zoning district. Other restricted uses include junkyards, waste transfer or disposal, land mining and stockyards. Any proposed uses must follow the acquisition of a Performance Standards use permit. Performance Standards uses are not permitted that exceed New York State regulations or other standards listed in the zoning codes book, such as standards for noise, odor emission, dust emission, and vibrations, as measured at the individual property line.

Zoning in the Linde property vicinity includes a business district to the north, a low-density residential area to the west, and the Performance Standard District to the south and east.

Because the west boundary of the site abuts a residential zone, construction of an institution for human health care or treatment or a dwelling unit are not strictly prohibited under the Performance Standard zoning category. However, given the past and current use of the Linde Site for industrial and commercial uses for more than 60 years, USACE has concluded that the reasonably anticipated future land use of the property will be for industrial/commercial purposes (USACE 2000).

2.3 Physical and Environmental Site Characteristics

The physical and environmental characteristics of the Linde Site are described in detail in the RI report (BNI 1993), the FS report (DOE 1993a), the Addendum to the FS for the Linde Site (USACE 1999a), and the ROD for the Linde Site (USACE 2000). An overview of physical and environmental characteristics of the Linde Site is presented in the following paragraphs.

The Linde Site is relatively flat and is situated on a broad lowland east of Twomile Creek a tributary of the Niagara River. The elevation of the ground surface is approximately 600 ft above mean sea level at the Linde Site (BNI 1993). Twomile Creek begins south of Linde in a natural channel. Near the southern boundary of the Linde site, flow in Twomile Creek is directed into twin subsurface box conduits which traverse the Linde Site, underground. Stormwater runoff from Linde is collected in the facility's stormwater system and is discharged through two large flow control gates located on the downstream face of the concrete dam that impounds Sheridan Park Lake. Downstream of the Sheridan Park Dam, the natural channel of the Twomile Creek conveys flow in a generally northerly direction to the Niagara River, approximately 2¼ miles north of the Linde Site (see Figure 2).

Mapping of regional glacial and bedrock geology indicates that the site area is situated on clayey glacial till and glaciolacustrine units directly overlying the Camillus Shale of the Salina Group. This formation is approximately 400 feet (ft) thick in the area and consists predominantly of gray, red, and green thin-bedded shale and massive mudstone. Interbedded with the shale and mudstone are relatively thin beds of gypsum, dolomite, and limestone.

Boring logs for eight (8) monitoring wells constructed at Linde during the RI show that bedrock was encountered at depths ranging from approximately 82 to 96 ft (BNI 1993). In borings for the construction of three deep monitoring wells at the Site in 2001, bedrock was encountered at depths ranging from approximately 72 to 85 ft (USACE 2003b). The locations of wells installed during the RI and wells installed by USACE in 2001 are shown in Figure 4. Based on numerous soil borings, the RI report indicates that the natural soils at Linde appear to be covered by a fill layer ranging in thickness from 0 to 17 ft. The fill contains substantial quantities of slag and fly ash that was apparently brought on-site from local sources for grading purposes during the construction of the Linde facility (BNI 1993). Undisturbed soils that underlie the site are composed primarily of clay and sandy clay. These soils have low permeabilities precluding significant infiltration of precipitation.

Years of continuous industrial activity at the Linde Site have left only marginal areas for natural plant communities. The property provides minimal urban wildlife habitats, supporting only cosmopolitan species of birds and small animals (DOE 1993b).

A review of National Wildlife Inventory (NWI) maps (Tonawanda West and Buffalo Northwest quadrangles) identified no floodplains or wetlands on-site at Linde.

Except for occasional transients, no federally-listed or proposed endangered or threatened species under jurisdiction of the United States Fish and Wildlife Service (USFWS) have been sighted in the project area and no listed or suspected critical habitats occur on the Linde Site (DOE 1993c).

Groundwater at the Linde Site is addressed in Sections 3 and 4, below.

2.4 Ongoing Remediation at the Linde Site

As noted above, remediation of soils and structures at the Linde Site, in accordance with the 2000 ROD, has been underway since June 2000. When the remedy for soils and structures was selected, USACE determined that the cleanup standards found in 40 CFR Part 192, the standards for cleanup of the uranium mill sites designated under the Uranium Mill Tailings Radiation Control Act (UMTRCA) and the Nuclear Regulatory Commission (NRC) standards for decommissioning of licensed uranium and thorium mills, found in 10 CFR Part 40, Appendix A, Criterion 6(6), are relevant and appropriate for cleanup of FUSRAP eligible COCs in soils at the Linde Site. The major elements of this remedy involve excavation of soils with COCs (radium, thorium and uranium) above the soil cleanup levels, placement of clean materials to meet the other criteria of 40 CFR 192, and cleanup of contaminated surfaces in buildings with COCs above the surface cleanup levels.

The remedy selected in the 2000 ROD also involves the demolition/relocation of buildings necessary to remediate the site. The remediation addressed in the 2000 ROD also includes remediation of the adjacent Niagara Mohawk and CSX Corporation (formerly Conrail) properties, where radioactive contamination has already been identified or may be identified as the remediation work is implemented. The remediation is limited to FUSRAP eligible COCs. The remediation plan also includes the removal of contaminated sediments from drainlines and sumps and the removal of contaminated soil from a blast wall structure located east of Building 58. Completion of site remediation addressed in the 2000 ROD is planned in 2009.

The remedy selected by USACE for the Building 14 OU at the Linde Site is referred to as Removal. Implementation of this remedy involved demolishing Building 14 and removing the building demolition debris from the Linde Site (USACE 2003a). The utility tunnel located beneath Building 14 was relocated to allow for removal of contamination within and around the tunnel structure. Building components and soils under the building were surveyed to determine the materials and soils that are retroactively contaminated with COCs (radium, thorium, and uranium) above the cleanup criteria. All materials and soils were disposed at permitted/licensed facilities. The Building 14 OU work was completed in 2005.

3. GROUNDWATER AT LINDE AND INJECTION OF MED/AEC WASTES INTO LINDE GROUNDWATER

Details of groundwater flow characteristics at Linde and detailed descriptions of the injection of MED/AEC wastes into Linde groundwater are provided in the FS (USACE 2004), the 1993 RI report (BNI 1993), and the 1981 Aerospace report (Aerospace 1981). Relevant information is summarized below.

3.1 Site Stratigraphy and Groundwater

The descriptions of subsurface conditions (both geology and hydrogeology) provided in the 1993 RI report are based on subsurface investigations conducted by DOE at the four Tonawanda FUSRAP Site properties, Ashland I, Ashland II, Seaway, and Linde.

The RI report divided the geologic units encountered during drilling activities into the two following categories:

- **Unconsolidated Material.** This refers to the sediments/fill that overlie the bedrock at each of the four sites. In Tonawanda, these units have generally been encountered in the following order from shallowest to deepest: fill, till, varved lacustrine clay, glaciolacustrine deposits, and at the Linde Site, coarse-grained fluvial or glaciofluvial deposits. At the Linde Site, the fluvial or glaciofluvial deposits directly overlie the bedrock.

- **Bedrock.** The bedrock encountered during drilling activities at the four Tonawanda FUSRAP sites is composed of the siltstones, shales, and dolomites of the Silurian Salina Group. The upper 6 to 15 feet of the bedrock "showed moderate to extensive fracturing that in some cases were filled with gypsum".

To illustrate the relationship between the bedrock and the overlying unconsolidated sediments at the Linde Site, a cross sectional drawing of the subsurface at Linde was developed incorporating subsurface information from the 1993 RI report and information from the investigations conducted at Linde by USACE in 2001. The location of this cross section, referred to as cross section A-A, is shown in Figure 5 and the cross section is shown in Figure 6.

In the 1993 RI report, the following three "hydrogeologic systems" were identified based on the results of the investigations conducted at the four Tonawanda FUSRAP sites:

- A **perched zone**, which is defined in the 1993 RI report as occurring within the fill and upper portion of the till. Monitoring wells were not installed in the perched zone during the previous investigations at the four FUSRAP sites (BNI 1993). During the 2001 USACE investigation, the depth of fill encountered during borings for the three shallow wells was minimal and, therefore, the shallow wells installed at Linde in 2001 were not screened in the perched zone. Additional details of the 2001 investigation are described in Section 4.

- A **shallow, semi-confined system** that was encountered at depths ranging from 16 to 40 feet below ground surface (bgs) at the Ashland 1 and 2 sites (BNI 1993). During the 2001 USACE Linde investigation, the shallow semi-confined aquifer was encountered between seven and nine feet bgs in 2001 borings LMW-01, LMW-02, and LMW-03, as shown in Figure 6. The June 2001 piezometric surface for the semi-confined system, as measured in monitoring wells installed at Linde at these locations, is also shown in Figure 6.

- A **contact zone aquifer** that encompasses both basal unconsolidated materials and the underlying fractured weathered bedrock. Prior to the 2001 USACE groundwater investigation, only the contact-zone aquifer was characterized at the Linde Site with the installation of eight contact-zone aquifer monitoring wells. These eight wells are identified as B29W1D, B29W3D, B29W5D, B29W7D, B29W9D, B29W10D, B29W11D, and B29W13D in Figure 4. During the 2001 Linde groundwater investigation, three new monitoring wells were installed in the contact zone aquifer, wells LMW-04, LMW-05, and LMW-06. These wells were screened at depths below the ground surface of approximately 75 feet (ft) to 95 ft; 65 ft to 85 ft; and 88 ft to 118 ft, respectively, reflecting variations in the depth to the contact zone across the Site. The piezometric surface for the contact zone aquifer measured in June 2001 in well LMW-06 and existing wells B29W5D and B2911D, are shown in Figure 6.

For simplification in the FS and this PP, groundwater in the shallow, semi-confined system is referred to as shallow groundwater. The groundwater in the contact zone aquifer is referred to as deep groundwater.

The RI report indicates that because of the low permeability of the glacial till and clays, very little infiltrating water percolates to the shallow groundwater; therefore, little contaminant transport takes place. Most of the infiltrated water moves horizontally through the relatively higher conductivity top fill layer [1 x 10^{-3} centimeters/second (cm/s)] forming the thin perched groundwater system. This perched flow is the major subsurface transport mechanism, and according to the RI report, the perched water system is recharged locally and discharges into drainage ditches and creeks. The average distance to a surface discharge point (such as a stormwater drainage ditch) at Linde is approximately 100 ft. At Linde, the average velocity of perched water flow is estimated to be about 33 meters/year (m/yr) [108 feet/year (ft/yr)]. The shallow system is considered to be semi-confined because the clayey and sandy gravel component is surrounded by silty-clay material that has lower hydraulic conductivity (less than 10^{-7} cm/s) (BNI 1993). Surface water sampling at and downstream of Linde during the RI found no impact attributable to the Site.

The RI report notes that the hydraulic conductivity of the glaciofluvial deposits directly overlying the bedrock was not measured at Linde. The RI report further notes, however, that geologic descriptions and gradation analyses suggest that these materials (referred to as gravelly sand, some clay in Figure 6) could be described as silty sand.

The RI report estimates that these basal glaciofluvial deposits have a hydraulic conductivity of 2.3 x 10^{-3} cm/s (2,400 ft/yr) based on published hydraulic conductivity data for silty sand. Using an effective porosity of 0.13 and hydraulic gradient of 0.0003, the average linear groundwater velocity was calculated in the RI report to be 1.7 m/yr (5.5 ft/yr). Piezometric surface maps of the contact-zone aquifer show that there is no significant recharge or discharge for this aquifer at the Tonawanda site (BNI 1993).

At Linde, contaminated effluent was injected directly into the contact zone aquifer. Groundwater flow conditions and adsorption in the rock matrix affect the transport of contaminants in this aquifer (BNI 1993). During the injection, wells plugged frequently due to precipitation of the materials injected into the wells once they contacted the dissimilar water chemistry in the aquifer. Wells were cleaned frequently, often on a monthly basis. These cleanings would have presumably removed contaminated material from the wells, thus reducing the amount of source material available for future transport. Also, precipitation of injected material put it into a much less soluble form that would also minimize transport potential.

The shale underlying the basal glaciofluvial deposits shows moderate to extensive fracturing in the top 6 to 15 feet. The 1993 RI report notes that thirty-five (35) constant-head packer tests were conducted at various depths in Linde bedrock. Twenty-eight (28) of the packer tests at Linde had no water “take” (no water flow through the packer apparatus). The RI report used only the seven (7) packer test results showing water “take” to calculate a geometric mean hydraulic conductivity of 7.1 x 10^{-5} cm/s (80 ft/yr) for the bedrock at Linde. The 1993 RI report assumed that the upper bedrock is equivalent to a porous medium due to extensive fracturing in this region, and, assuming a porosity of 0.1 percent and a hydraulic gradient of 0.0003, estimated the linear velocity of the groundwater to be 24 ft/yr.

3.2 Groundwater Flow Directions – 2001 and 2002 Investigation

Groundwater elevations in the eight older wells and the six monitoring wells installed by USACE in 2001 were gauged in March and June 2001 prior to sampling. Figures 7 and 8 show the piezometric contours as determined from gauging the deep wells in March and June 2001. Since a complete set of water levels was not collected in August 2002, a piezometic surface map was not constructed for the August 2002 data. The piezometric contours were developed using the SURFER® code which assumes a linear relationship between elevation data points and develops contours to simulate points of equal elevations.

The piezometric contours for the contact zone aquifer, as indicated in the figures, show the groundwater flow direction to generally be to the southeast in March 2001 and to the southwest in June 2001. There are some local anomalous readings, such as the difference in elevations in groundwater gauged in wells B29W10D and LMW-06, which are adjacent to one another. (There was a 0.19 ft difference in these elevations in March 2001 and a 0.39 ft difference in these elevations in June 2001. Monitoring wells B29W10D and LMW-06 are screened at different intervals, which may result in variations in groundwater elevations between these monitoring wells.) Overall, the gradients across the site are small. For example, the water level elevation difference between well B29W07D and B29W05D, located about 2,150 ft southwest, was 0.21 ft in June 2001, or a gradient of 0.0001. The June 2001 groundwater flow direction and gradient information for the deep aquifer determined during the 2001 investigation are generally consistent with the information reported in the 1993 RI report, which indicates that flow in the deep aquifer is to the southwest. The March 2001 flow direction data appears to be anomalous. Groundwater elevation measurements were made in several of the deep wells prior to sampling in August 2002. As in the earlier measurement in 2001, groundwater elevation differences across the Site were small. The shallow gradient and associated flow directions at Linde can be easily affected by transient water levels (areas of the aquifer that recharge/discharge at different rates) and variable barometric fluctuations (“bouncing” the confined heads); these conditions manifest variations in local heads that can then cause site-wide interpretations to appear anomalous. No changes to the conclusions on groundwater flow direction were made based on the 2002 measurements.

The groundwater elevations observed in the contact zone aquifer are also consistent with the findings of the RI report that the contact zone aquifer is under confined conditions, with the hydraulic head rising 40 to 55 ft above the contact zone.

3.2.1 Shallow Wells

Groundwater elevation data are limited for the shallow wells. The reported groundwater elevations show elevations in the shallow wells 25-30 ft above the elevations for the deep wells in the contact zone aquifer, which is consistent with the presence of a low conductivity layer separating the shallow and deep systems, as reported in the RI report.

3.3 Overview of Uranium Ore Processing and Effluent Disposal at Linde in the 1940’s

Tax mapping property information for the Town of Tonawanda indicates ownership of the property at the Linde Site location by Union Carbide, Linde Division, in 1936. Commercial industrial processes were being conducted at the Linde Site by the Linde Air Products Division of Union Carbide prior to

MED/AEC-related operations in the 1940's. Union Carbide operations continued at the Linde Site after the MED/AEC-related activities ceased. In the 1990s, Praxair acquired the property and continued commercial industrial processes focusing on research and development (USACE 2000). Any FUSRAP remedial action at Linde would not involve and would not respond to any releases to the groundwater, or other media at the site, except those which are authorized for response under the FUSRAP program and related to the historical site operations conducted by the Linde Air Products Company for the MED/AEC program.

As described in the RI report, uranium ore processing was conducted at Linde by the Linde Air Products Company under an MED/AEC contract in the 1940's. Linde was selected for the contract because of the company's experience in the ceramics business, which involved processing uranium to produce the salts used to color glazes (BNI 1993). A three-step process was used to separate uranium from the uranium ores and tailings: in Step I ores and occasional residues (from Step II operations and other MED/AEC-related processes) were processed to produce uranium oxide; in Step II, uranium oxide was converted to uranium dioxide; in Step III, uranium dioxide was converted to uranium tetrafluoride. Residues from Steps II and III were recycled, whereas Step I produced large amounts of liquid and solid residue. The liquids were discharged into storm sewers, sanitary sewers and into the on-site injection wells. USACE has no knowledge of whether the wells used for disposal of the MED/AEC wastes were used for other waste disposal before, during or after the MED/AEC-related operations. USACE did not do a detailed investigation to determine whether there were other non-MED/AEC related uses of the injection wells, since there was more than enough documented evidence that they were used for MED/AEC-related activities and therefore, had to be addressed for FUSRAP eligible COCs. The history of injection of MED/AEC wastes into the deep groundwater at Linde is documented in the 1981 Aerospace report (Aerospace 1981).

In April 1944, the company began disposing of the liquid wastes in on-site wells. From 1944 to 1946, seven on-site wells were used during various periods of time for disposal of the liquid wastes. Available information suggests that the wells would plug, overflow, and have to be cleaned or replaced.

The seven wells were located in two main areas: three wells located in the area of Plant No. 1 (present Building 8) and four wells located near the Ceramics Plant (the former Buildings 30 and 38). The locations of the former injection wells are shown in Figure 4. It is reported that the injection wells ranged from approximately 90 to 150 ft in depth and were drilled into bedrock. Neither the 1993 RI report nor other reports provide information on the volumes of effluent that were discharged to each of the individual injection wells but the RI report indicates that the total estimated volume of effluent discharged into the injection wells was approximately 55 million gallons.

Information available in 1981 indicates that the filtrate discharged into the sewer or wells was a high pH solution (above a pH of 10) consisting mainly of ions from excess sodium sulfate, sodium carbonate, and sodium hydroxide. In addition, some chloride ions from the barium chlorides added to enhance radium recovery would also have been present, along with a small amount of a variety of complex anions of the many minor elements such as vanadium, nickel and cobalt. Small concentrations of uranium and radium were also present (Aerospace 1981). Molybdenum, present predominantly in the African ores, would have stayed in solution when uranium was precipitated and would thus be present in the waste effluent.

The weekly averages of uranium oxide concentrations in the effluents analyzed from April 1944 to July 1946 (from progress reports) ranged between 0.011 and 0.064 grams per liter (g/L). It was estimated that approximately 12,000 pounds (lbs) of uranium oxide were discharged to the injection wells. The 1981 Aerospace report, the principal source of information on the injection of MED/AEC waste at Linde, estimates that approximately 3 curies (Ci) of natural uranium were discharged to the subsurface at Linde. While not specifically calculated in the Aerospace report, using these estimates and the estimated 55 million gallons of wastes discharged, the average concentration of natural uranium in the liquid wastes discharged to the subsurface would have been approximately 14,400 picocuries per liter (pCi/L).

The 1981 Aerospace report (Aerospace 1981) states that only limited data are available regarding the radium concentrations in the effluent injected. It was estimated that about 0.52 Ci, or about 0.5 grams, of radium was discharged to the injection wells at Linde.

3.4 Contaminant Fate and Transport in Deep Groundwater as Described in the 1993 RI Report

The findings and conclusions concerning the fate and transport of wastes injected into deep groundwater at Linde, as reported in the 1993 RI report, are detailed in the FS and summarized below.

As described above, the RI report indicates that approximately 55 million gallons of liquid waste effluent, containing approximately 12,000 lbs of dissolved uranium oxide, was injected into the subsurface at Linde in the 1940s. The RI report states that this effluent, which contained primarily ions of sodium, sulfate, sodium carbonate, sodium bicarbonate, and chloride, was injected at a temperature of approximately 60°C (140°F). The 1993 RI report also indicates that minor concentrations of vanadium, cobalt, nickel, molybdenum, uranium, and radium were also present in the effluent. This liquid had a pH above 10 and a total dissolved solids (TDS) concentration greater than 20,000 parts per million (ppm). The RI report notes natural formation water in the bedrock units contains significantly lower concentrations of the major ions and TDS; the water temperature is 12°C (54°F); and the pH is approximately neutral (7.0 to 7.5).

Based on the above scenario, the RI report concludes that the nature of the subsurface contamination is probably in the form of mineral precipitates of uranyl sulfates and carbonates in the fractures and pore space of the Salina Group shale. As detailed in Section 4.5, subsequent sampling and modeling by USACE has confirmed these conclusions.

Based on the findings of the RI, the RI report concludes that contamination in the contact zone (deep) aquifer is from well effluents at Linde and only very soluble metals such as molybdenum were detected in this aquifer. As further described in Sections 5.1 and 5.2, the naturally elevated background concentrations of TDS and constituents such as sulfates in the deep groundwater at and in the vicinity of Linde are unacceptable absent any injection of wastes.

3.5 Contaminant Fate and Transport in the Perched and Shallow Groundwater as Described in the 1993 RI Report

The details of contaminant fate and transport in the perched and shallow groundwater at Linde, as described in the 1993 RI report, are summarized below.

The RI report notes that Linde is generally covered by a thin veneer of coarse-grained fill material (0 to 4 ft thick) with localized pits and old building foundations that contain fill to depths as great as 17 ft and that undisturbed sediments that underlie the surface fill material are composed primarily of clay and sandy clay. The RI report observes that these soils have low permeability, which precludes infiltration of significant quantities of precipitation, and that infiltrating water (perched zone) tends to flow laterally along the contact surface of the undisturbed sediments in the fill material and discharges into streams and wetlands where the natural clay materials are at the surface. Subsurface ponding occurs in the buried pits and old building foundations containing fill material. Water trapped in these areas will percolate downward at a slow rate because of the low permeability of the underlying clays. Flow directions in the fill material generally correspond to the surface topographic configuration. No monitoring wells were installed at Linde during the RI to determine water quality in either the perched or the shallow groundwater. As described below, shallow groundwater monitoring wells were installed by USACE at Linde in 2001.

The RI report states that the primary pathway of contaminant transport through subsurface soil is via the perched groundwater system. Because of the natural clays underlying the properties, vertical percolation of recharge water to the shallow groundwater system is minimal; therefore, the potential for contaminant migration to the shallow groundwater system is reduced. The RI report indicates that water infiltrating through the contaminated soils may leach contaminants and transport them to the perched groundwater system. The perched system, which follows the contour of the top of the natural clays, transports the contaminants to nearby discharge points in the surface drainage systems. The RI report indicates, however, that sampling of surface water at locations upstream and downstream of the Linde Site was conducted during site characterization activities in 1988 and 1989. The results of the sampling show surface water was not impacted by radionuclides from the Site, when upstream and downstream results are compared. These samples were taken prior to the remediation of soils that has been underway at Linde since 2000. By removing tens of thousands of tons of soil contaminated with radionuclides from the Site, USACE greatly reduced the potential for leaching of radionuclides to groundwater or contaminant discharge to surface water.

The RI report concludes that the results do not indicate that the FUSRAP eligible radionuclides and metals are migrating at a detectable rate into the natural clays below the property. However, removal of the source term as a result of the remedial actions for soils serves to all but eliminate the source for this migration pathway.

4. SUMMARY OF FINDINGS OF LINDE GROUNDWATER INVESTIGATIONS BY USACE IN 2001 AND 2002

As described in Section 1.3, earlier reports that addressed the Linde Site, including the 1993 RI report (BNI 1993), the 1993 BRA (DOE 1993c) and the 1993 FS report (DOE 1993b), had concluded that no remedial action was warranted for Linde groundwater. The 2000 USACE ROD for the Linde Site (USACE 2000) also concluded that no remedial action is warranted for Linde groundwater. This conclusion was based on evaluation of the earlier reports, including the 1993 BRA, which concluded that a completed exposure pathway does not exist for groundwater at the Tonawanda FUSRAP Sites because groundwater is not potable (DOE 1993c). The investigations of Linde groundwater in 2001 and 2002 were conducted by USACE to supplement the information available in 1993 and address data gaps identified during meetings with agency representatives.

The principal investigation activities in 2001 included:

- construction of 3 new deep monitoring wells and the construction of 3 new shallow monitoring wells;
- two groundwater sampling rounds (March and June, 2001), with sampling conducted at the new and existing monitoring wells;
- analyses of filtered [with a 0.45 micron (μm) filter] and unfiltered groundwater samples from these wells for the presence of radionuclides and metals, and also analyses of unfiltered samples from these wells for general chemistry parameters; and
- collection of soil samples for radionuclide analyses and leaching tests.

The principal investigation activities conducted in 2002 included:

- a groundwater sampling round (August 2002), with sampling conducted at the new monitoring wells constructed by USACE in 2001 and selected older monitoring wells that were constructed by DOE;
- analysis of filtered and unfiltered groundwater samples from these wells for the presence of radionuclides and metals; and
- collection of soil samples for radionuclide analyses and leaching tests.

The investigations conducted and their findings are briefly summarized in the following sections. Additional details are provided in the USACE report, *Results of the 2001 and 2002 Groundwater Investigations at the Linde Site* (USACE 2003b).

4.1 Description of the Field Investigations in 2001

4.1.1 Investigation to Assess Deep Groundwater - Deep Monitoring Wells

Three deep monitoring wells were installed as part of the 2001 field investigation. New monitoring well LMW-06 is located near Building 8 in the vicinity of the former injection wells near Building 8 and in close proximity to boring L1WRO-01, which was drilled as part of the second phase of the DOE RI (1990-1991). The 1993 DOE RI report notes that elevated gamma readings were noted in this boring (L1WRO-01), which was located about one ft from a former injection well and a yellow precipitate was observed from a thin fracture of the bedrock core from this boring. This precipitate was encountered at a depth of approximately 100 feet during the RI. During the boring for new well LMW-06 in 2001, it was planned that an attempt would be made to obtain a sample of this precipitate and test the sample to determine the potential for leaching of the material into groundwater. During the boring for new well LMW-06 in February 2001, this yellow precipitate was not observed and no samples were retrieved for leaching tests.

Based on information in the 1993 RI report and measurements by USACE in March 2000, it was determined that the groundwater flow direction in the contact (deep) zone aquifer at the site is generally southwesterly. USACE reviewed site conditions and the locations of the existing deep monitoring wells and determined, in concurrence with NYSDEC and USEPA representatives, that two additional deep monitoring wells, LMW-05 and LMW-04, in addition to new well LMW-06, were required to better assess whether MED-related constituents in the injected effluent have had an unacceptable impact on water quality.

New deep monitoring well LMW-05 is located approximately 1,800 ft southwest of the former injection wells near former Buildings 30 and 38. New deep monitoring well LMW-04 is located approximately 1,300 feet southwest of the former injection wells near Building 8. The locations of the three new deep monitoring wells installed in 2001, LMW-04, LMW-05, and LMW-06, are shown in Figure 4.

4.1.2 Investigations in 2001 to Assess Potential Impacts to Shallow Groundwater

Shallow groundwater at the Linde Site is separated from the deep, contact zone groundwater by a thick layer of till and clay. No monitoring wells were installed during the RI by DOE to monitor shallow groundwater at Linde and no shallow groundwater elevation data were available prior to investigations conducted by USACE in 2001. Information in the 1993 RI report indicates, however, that shallow groundwater flow is presumed to flow laterally with topography toward natural or manmade surface water drainage ways present at the Site.

To assess the potential for impacts to shallow groundwater, leaching tests and groundwater investigations were conducted as described below.

4.1.2.1 Soil Sampling and Leaching Tests – 2001 Investigations

Samples of the site soil during on-going soil remedial activities were collected in March 2001 and subjected to leaching tests to determine the potential impacts to shallow groundwater. The soil samples were analyzed for total activity of uranium, radium, and thorium isotopes and also subjected to a modified California Waste Extraction Test (WET), which is similar to the Toxicity Characterization Leaching Procedure (TCLP) test, using an organic acid leaching solution. The results of the analysis of the radionuclide concentrations in the soil and in the final extract solutions allow for a direct comparison between total and leachable activities (concentrations) providing an indication of the potential for contaminant mobility. Section 4.4, below, describes the results of the leaching tests.

4.1.2.2 Shallow Monitoring Wells – 2001 Investigations

Three shallow monitoring wells were installed as part of the field investigation: LMW-01, LMW-02 and LMW-03. Borings were advanced to depths of 20 to 25 feet and the wells were installed with 10 ft screens. Subsurface conditions at the locations of these shallow wells are shown in Figure 6.

These wells were sampled as part of the 2001 investigation. (Note: No groundwater samples were taken from LMW-02 due to slow recharge.) The locations of the three shallow monitoring wells installed in 2001, LMW-01, LMW-02, and LMW-03, are shown in Figure 4.

4.1.3 Downhole Gamma Scans – 2001 Investigations

After the new monitoring wells were installed, downhole gamma scanning was performed in the six new wells and the eight existing monitoring wells installed during the RI. These scans were conducted to assess the potential that radioactively contaminated material injected into the subsurface may be present at the strata where deep wells were constructed and to assess the potential for the presence of radioactive material in the till above the clay strata at the shallow well locations. The details of the downhole gamma scans are available in the report entitled *Borehole Geophysical Survey Report at the Linde FUSRAP Site, Tonawanda, New York (SAIC 2002).* The downhole scans produced results in counts per second (CPS) and may identify elevated levels of gamma-emitting radionuclides but can not be used to identify specific radionuclide constituents. At well LMW-06, elevated gamma levels were seen at approximately 89.9 ft below the ground surface, approximately at the depth where the underlying bedrock begins. Elevated gamma readings were also observed in well B29W-10D, located about 4 ft from well LMW-06. The elevated readings in B29W-10D were seen at a depth of approximately 96 ft. Elevated gamma readings were not observed in the deep subsurface at other site locations. Historically, radioactive-impacted wastewaters was injected into the "contact-zone aquifer" which is encountered between 80 and 119 feet below ground surface at the site. The report concluded that the elevated gamma measurements in wells LMW-06 and B29W-10D may correspond to either radioactively impacted contact-zone aquifer (deep groundwater) or geologic materials impacted by previous injections. Wells LMW-04 and LMW-05 showed increased average gamma radiation in the shallower subsurface at depths of 42-63 ft and 35-44 ft, respectively. These increased gamma elevations were attributed to geologic variations and the presence of increased clay material. Three wells (LMW-01, LMW-02 and LMW-03) exhibited elevated gamma activity very near to the surface (2 to 6 ft below ground surface). These zones are interpreted to represent radioactively impacted soils, which are being remediated at Linde.

4.1.4 Groundwater Sampling and Analyses – 2001 Investigations

Groundwater samples were collected from five of the six newly installed monitoring wells and the eight existing monitoring wells in March and June 2001 (LMW-02 was not sampled in March and June 2001 due to slow recharge). Unfiltered samples and filtered samples were analyzed for the presence of radionuclides including radium isotopes, thorium isotopes, uranium isotopes, gross alpha radiation, gross beta radiation and total uranium. Unfiltered and filtered samples from the wells were also analyzed for the presence of target analyte list (TAL) metals. Unfiltered samples from the wells were also analyzed for general chemistry parameters.

4.2 Groundwater Investigations in 2002

The groundwater investigations at Linde in 2002 included groundwater sampling and analyses, the analysis of soil samples and soil sample leaching tests as described in the following sections.

4.2.1 Groundwater Sampling and Analyses in 2002

In August 2002, groundwater samples were collected from five of the six monitoring wells that were installed at Linde by USACE in 2001 (shallow wells LMW-01 and LMW-03, and deep wells LMW-04, LMW-05, and LMW-06), and three of the previously installed monitoring wells (deep wells B29W05D, B29W07D, and B29W09D). The locations of these monitoring wells are shown in Figure 4. Sampling and analyses of the groundwater samples was conducted in accordance with the SAP (USACE 2001), and the SAP Addendum (USACE 2002b). Like the previous two sampling rounds (March and June 2001), insufficient groundwater recharge precluded the sampling of well LMW-02 in August 2002.

As described in the SAP Addendum (USACE 2002b), the eight (8) monitoring wells sampled in August 2002 were selected for sampling based on previous analytical results.

Unfiltered samples and filtered samples were analyzed for the presence of radionuclides including radium isotopes, thorium isotopes, uranium isotopes, gross alpha radiation, gross beta radiation and total uranium. In addition, unfiltered and filtered samples from the wells were analyzed for the presence of TAL metals and boron and molybdenum.

4.2.2 Soil Sampling and Leaching Tests – 2002 Investigation

As in the investigations conducted in 2001, several samples of site soils were collected at the Linde Site in August 2002 and subjected to leaching tests. These tests were conducted to determine potential impacts to shallow groundwater. The results of leaching tests are described in Section 4.4.

4.3 Evaluation of Groundwater Results

The results of the groundwater sampling at Linde in 2001 and 2002 are included in the FS report (USACE 2004) and associated addendum (USACE 2005).

The highest concentrations of constituents in deep groundwater considered to be present in the MED/AEC discharges to the deep groundwater at Linde were detected generally in close proximity to the former injection well locations. The highest concentrations of total uranium were 837 µg/L and 765 µg/L, respectively, in unfiltered samples from monitoring wells LMW-06 and B29W10D in March 2001, as shown in Table 1. In June 2001, only relatively low levels of total uranium were detected in samples from these wells. In August 2002, the unfiltered sample from LMW-06 showed a much lower concentration of total uranium than in March 2001. (Wells B29W10D and LMW-06 are located adjacent to one another and B29W10D was not sampled in August 2002.) These wells are located in the vicinity of the former injection wells near Building 8. With the exception of one anomalous reading in the sample from LMW-06 in March 2001, radium-226 (Ra-226) and radium-228 (Ra-228) levels were low (see Table 2). All thorium-232 (Th-232) and thorium-230 (Th-230) results were low (see Table 3). The highest concentration of molybdenum, also considered to be associated with the MED/AEC discharges to the deep groundwater at Linde, was detected at 0.45 mg/L in well B29W09D, which is in the vicinity of the former injection wells located near former Buildings 30 and 38 (see Table 4).

As described above, the shallow groundwater at Linde is separated from the deep groundwater by a thick clay layer. The injection of MED/AEC wastes at Linde was to the deep groundwater, and therefore, the injected waste would not be expected to impact the shallow groundwater. The results of analyses of shallow groundwater samples at Linde show the highest concentration of uranium (total) in an unfiltered sample from MW-03 in March 2001. The results from the samples in June 2001 and August 2002 were slightly lower.

Soils and buildings contaminated during MED-related operations have been the subject of extensive remediation by USACE, thus removing potential sources for any future contamination of the shallow groundwater at Linde. Based on the remediation of the soils and buildings and the results of the USACE investigations, USACE has determined that no further actions are necessary for addressing the shallow groundwater.

4.3.1 Variation in Groundwater Sample Results - March and June 2001 and August 2002

The March 2001 and June 2001 sample results show substantial variation in the case of uranium at two locations and in the radium at one location. In some cases, the variation is one to two orders of magnitude. As examples, the total uranium in the unfiltered sample from LMW-06 in March 2001 is 837 µg/L, while the total uranium in the unfiltered sample from the LMW-06 in June 2001 is 17.9 µg/L. The results from the August 2002 sample round generally show a continuing downward or steady trend, for all analytes except uranium (isotopic and total). In August 2002, the total uranium concentration in LMW-06 was 98.8 µg/L, compared to 17.9 µg/L in June 2001 in the unfiltered sample. A similar trend is observed in the filtered samples and in the results of the metals analyses.

In the deep wells, elevated levels of MED/AEC constituents were seen only in the new wells, LMW-06 and LMW-05, and in older well B29W10D, which is immediately adjacent (less than 4 ft) to new well LMW-06. It is believed that a solid phase of some of the MED/AEC constituents may have been temporarily mobilized as part of monitoring well installations in early 2001. The new wells were installed using a Rotosonic® drill, which imparts high energy levels to the formation as drilling occurs through vibration, rotation, and downward pressures. It is believed that the high energy transmitted locally to the formation resulted in a temporary mobilization of the immobilized (or mineralized) residues present in the formation near the injection wells as the drilling proceeded. In the first sampling round in March 2001, the mobilized residues containing radionuclides were still present and the results of the analyses reflected elevated levels of radionuclides, most notably, uranium.

There are numerous variables, both environmental and analytical, that may also contribute to variations in the results. Some of the environmental variables would include variations in groundwater elevations and mechanical variables such as purging and sampling methods. The analytical results could vary for samples with the same actual concentrations, but different results obtained [e.g., a small speck of radiological material (submicron size) passing through a filter could result in a much higher pCi/L concentration].

4.4 Results of Leaching Tests

4.4.1 Leaching Tests Conducted During Investigations in 2001

Five (5) soil samples (and one duplicate sample) were collected at the Linde Site on March 8 and 9, 2001. Two samples and one duplicate sample were collected from below the footprint of Building 30. Three samples were collected at a depth of 0.5 to 1.5 ft from an excavation near Building 73B.

These soil samples were subjected to the WET extractions to assess the potential for leaching. The WET test is aggressive and represents a worst case for leaching. The results found that the soils near Building 30, where various forms of the MED materials could be found (e.g., ore, residues, processed materials, uranium product, etc.), demonstrated that more of the uranium would leach from the soil than would from the soils around Building 73B under these aggressive conditions. The 2001 shallow groundwater results near Building 30 (LMW-03) show elevated levels of uranium whereas the results near Building 73B (LMW-01) do not. In both cases, the groundwater concentrations are much less than the leachate results from the WET extraction, which is expected, and better represents the potential for leaching under current site conditions. Both the WET extraction results and the groundwater sampling results support the conclusion that there is some potential for leaching of radionuclides (uranium) from site soils currently being remediated under a separate CERCLA action.

4.4.2 Leaching Tests Conducted During Investigations in 2002

Four (4) soil samples (and one duplicate sample) were collected at the Linde Site in August 2002. Two samples and one duplicate sample were collected from below the footprint of Building 30, in an area (Class 1 area[3]) where active soil remediation activities (soil removal) have occurred or were ongoing by USACE. Two additional soil samples were collected from Class 2 areas, where soil remediation is not planned, located along the northern property line and east of Building 90.[4]

The samples were analyzed for isotopic radium, thorium, and uranium. The samples were also subjected to the CAL WET (using an extraction fluid of pH 5) and modified-WET extractions (using an extraction fluid pH of 7.95, which is an average of the actual pH measured in Site shallow groundwater in 2001 and 2002).

Soils subjected to the CAL WET extractions show the potential for leaching. Samples subjected to the modified - WET extractions show significantly less leaching potential (see Table 5).

The leaching test results suggest that there is potential for leaching of radionuclides (uranium) from Site soils. It is noted, however, that the actual shallow groundwater concentrations of uranium are not significantly elevated. As reported in the 1993 RI report, there were no elevated levels of radionuclides detected in the surface water samples collected from Twomile Creek. Given the extensive excavation and removal from the Site of soil containing elevated levels of uranium and other radionuclides, potential sources for leaching of radionuclides to shallow groundwater are now greatly reduced and any potential for impacts are not significant.

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[3] Class 1 areas are areas that have, or had prior to remediation, the potential for radioactive contamination in excess of the cleanup criteria, or known radioactive contamination in excess of the cleanup criteria.

[4] Class 2 areas are areas that have not been remediated, that have a potential for radioactive contamination or known contamination, but are not expected to exceed the cleanup criteria.

4.5 Conceptual Model of Contaminant Fate and Transport Based on Current Information

4.5.1 Contact Zone Aquifer

The RI report concludes that liquid wastes containing radioactive constituents were injected into the subsurface in the 1940s and after injection moved under pressure through fractures in the bedrock and into the more permeable contact zone aquifer overlying the bedrock. The RI report further concluded that because the waste was higher in temperature and had a higher pH than the natural groundwater, the radioactive constituents in the waste precipitated to form relatively insoluble solid material within the bedrock fractures and contact zone formation. The RI report then describes the potential for transport of radioactive constituents within the fractured bedrock and contact zone as minimal due to immobility of the constituents and low hydraulic gradients in these formations. In summary, the RI report concludes that the radionuclides have precipitated from the groundwater and are now immobile (or mineralized) in the vicinity of the location where injection occurred. In the RI report, the field evidence of the conceptual model for the fate and transport of the injected radioactive constituents in the contact zone aquifer was limited, with only one set of validated groundwater sample results from one well (B29W10D) on one date.

The 2001 and 2002 field investigations at Linde included the construction of three new deep wells to monitor groundwater quality in the deep aquifer and three rounds of deep groundwater sampling (two rounds included sampling of the three new deep wells and the eight existing deep wells; in the third round the three new deep wells and three of the existing deep wells were sampled) with validation of all sampling results. The 2001 and 2002 investigations, thus, provide more complete field information to assess the conceptual model of fate and transport described in the RI report.

The findings concerning the groundwater flow direction and hydraulic gradient in the deep aquifer (groundwater flow southwesterly at a low gradient) determined from June 2001 groundwater elevation measurements are consistent with the 1993 RI report. The groundwater elevation measurements in March 2001 suggest a more southeasterly groundwater flow direction in some portions of the Site. The August 2002 elevation measurements are inconclusive. Based on historical measurements and the June 2001 measurements, it is concluded that a generally southwesterly groundwater flow direction exists in the deep aquifer.

The results of the March 2001 sampling show elevated levels of some of the radionuclides in the groundwater samples from wells LMW-06 and B29W10D, which are located near the former injection wells and in the sample from the LMW-05 which is located farther from the former injection wells. Elevated levels of radionuclides were not detected, however, in samples from these wells collected in June 2001. Subsequently, sampling at LMW-05 showed no elevated levels of radionuclides. The elevated levels of radionuclides detected in March 2001 at these three locations are attributed to the drilling method used to install the wells and the proximity of well B29W10D to new well LMW-06. It is concluded that the June 2001 and August 2002 samples are more representative of actual site conditions and elevated levels of radionuclides are not expected in the deep aquifer at Linde except in the area immediately adjacent to the former injection wells. These findings are consistent with the description of the fate and transport of the radionuclides injected into the deep aquifer as described in the RI report.

The PHREEQC geochemical model was used to further predict the potential fate of the uranium discharged to the contact zone aquifer at Linde in the 1940s. Site characterization data from the 1993 RI report and findings of the 2001 groundwater investigation were used in the modeling. The results of the modeling indicate that the soluble uranium present in the waste could precipitate under the natural conditions in the contact zone aquifer. The modeling predicts that uranium solubility under site conditions is approximately 0.04 mg/L or approximately 27 pCi/L. The evaluation further notes that groundwater monitoring shows high concentrations of uranium in monitoring well sediments (i.e., drilling residuals drawn into wells from the boreholes) and low concentrations of uranium in the groundwater, supporting the premise that uranium is remaining in the solid phase in Linde groundwater.

Estimates of the potential transport of uranium in the contact zone aquifer were made using a one-dimensional transport equation. Estimates assumed two cases, a single pulse source of uranium and a solubility-limited source. Based on these estimates, the assessment indicates that uranium should have been observed in monitoring wells during the 55 years since the injection occurred. Because the uranium has not been observed at the levels predicted, it is concluded that the premise is supported that the uranium has low solubility in the contact zone aquifer at Linde. This is consistent with the findings of the 1993 RI report.

4.5.2 Shallow Groundwater

As summarized above, the RI report describes the fate and transport of radionuclides in shallow groundwater in terms of potential horizontal flow with discharge to surface water, with a relatively impermeable layer precluding flow and contaminant transport vertically. No monitoring wells were installed in the shallow aquifer as part of the RI. Therefore, no field evidence of actual groundwater quality in the shallow aquifer was available at the time the RI report was prepared.

The 2001 investigation at Linde included the installation of three shallow monitoring wells and two rounds of sampling. Water quality data is not available for one of the wells (LMW-02), due to the low recharge rate for this well. The results from the shallow wells show no significant levels of radionuclides in the shallow groundwater.

Soil samples collected at Linde were subjected to leaching tests. The California WET and modified California WET were used. The results show that under the aggressive test conditions employed by WET, radionuclides, especially uranium, may be leached from the soil. These conditions are considered to be more conservative than actual conditions at the site. It is noted that actual shallow groundwater concentrations of uranium are not elevated.

The March 2001 groundwater samples from the shallow wells were taken prior to remediation of the areas surrounding LMW-01 and LMW-03. The March 2001 soils samples had significantly elevated uranium concentrations. The CAL WET leaching analysis showed a high potential for leaching to groundwater, yet this was not supported by the groundwater analytical results.

Results of sampling and analyses of shallow groundwater for the presence of metals and general chemistry parameters shows the presence of elevated levels of sodium, chloride and TDS in shallow groundwater from LMW-01 and elevated levels of sulfate and TDS in shallow groundwater from LMW-03.

Given the extensive excavation and removal from the Site of soil containing elevated levels of uranium and other radionuclides, potential sources for leaching of radionuclides to shallow groundwater are now greatly reduced and any potential for impacts are not significant.

5. POTENTIAL EXPOSURE SCENARIOS

A complete exposure pathway consists of at least the following four elements: (1) a source and mechanism of contaminant release to the environment (a receiving medium); (2) an environmental transport medium for a released contaminant; (3) a point of contact with a contaminated medium (an exposure point); (4) a route of exposure (an exposure route). If any of these elements are missing, the pathway is incomplete and is not considered in an evaluation of potential threats to human health and the environment.

USACE reviewed the historical accounts of the discharge of FUSRAP eligible constituents to the deep groundwater at Linde and determined that at that time (1940s) there was a release (by injection of liquid wastes) of FUSRAP eligible contaminants to the subsurface (the groundwater) and a medium for contaminant transport (also the groundwater) existed and still exists. Physical and chemical conditions in the deep groundwater have, however, precluded the transport of the FUSRAP eligible constituents and groundwater sampling confirms that any elevated levels of FUSRAP eligible contaminants are detected only in the immediate vicinity of the historical injection wells.

Based on this understanding of subsurface conditions, the potential for a human point of contact (with FUSRAP eligible COCs in deep groundwater) and a human exposure route (to contaminants in deep groundwater) was assessed. Ingestion of drinking water and ingestion of produce irrigated with groundwater from the Site, were addressed.

5.1 Drinking Water

To use deep groundwater at Linde as a source of drinking water a deep well or wells would first be required along with appropriate pumps and ancillary equipment. Assuming that there is a sufficient yield capability in a supply well, groundwater could be available at the source of the Linde Site.

As described below, the groundwater made available would not, however, be suitable for drinking without costly treatment.

An evaluation of upgradient (background) wells at Linde indicates that without even considering wells potentially impacted by MED/AEC-related operations, groundwater at the Linde site is naturally severely compromised. Relevant results of the June 2001 sampling at Linde are provided in the table below.

Background Wells

	Chloride mg/L	Sulfate mg/L	TDS mg/L	Iron mg/L	Manganese mg/L	Aluminum Mg/L	pH
Secondary MCL	250	250	500	0.3	.05	0.05 to 0.2	6.5-8.5
Well ID							
B29W01D	330	2400	4100	0.35	0.04	0.21	9.02
B29W07D	1700	3650	8050	1.65	0.33	1.55	8.99
B29W11D	540	2600	4700	0.43	0.07	.049	8.48

While the results above demonstrate exceedances of Secondary Maximum Contaminant Levels (SMCLs) (i.e., secondary drinking water standards) rather than Primary MCLs, there are still very tangible impacts to using water that exceeds the secondary standards. Secondary standards were developed to address cosmetic and aesthetic effects in drinking water (such as taste, odor, tooth discoloration, staining, etc.). Waters with the concentrations demonstrated above can lead to laxative effects, scaling and/or corrosion in pipes, staining of household fixtures, and add a salty taste to water. In particular, the scaling and corrosion effects may have significant economic implications.

The sulfate concentration in seawater is about 2700 mg/L (USEPA 2003); seawater concentrations are present at the Linde site. Further, sulfate is known to cause a laxative effect in adults at concentrations above the secondary standard, particularly when combined with high total dissolved solids. Additional material is referenced below, taken from *Drinking Water Advisory: Consumer Acceptability Advice and Health Effects Analysis on Sulfate*, U.S. Environmental Protection Agency Office of Water (4304T), EPA 822-R-03-007, February 2003.

"The sulfate concentration in seawater is about 2,700 mg/L (Hitchcock 1975) and ranges from 3 to 30 mg/L in freshwater lakes (Katz 1977). Sulfate content in drinking water ranges from 0 to 1,000 mg/L in the United States (Trembaczowski 1991)."

"A health-based advisory for acute effects (absence of laxative effects) of 500 mg of sulfate/L is recommended. This value depends on the absence of other osmotically active materials in drinking water, which could lower the sulfate level associated with a laxative effect. Where the water contains high concentrations of total dissolved solids and/or other osmotically active ions, laxative-like effects may occur if the water is mixed with concentrated infant formula or a powdered nutritional supplement." The document goes on to state that adults may adapt to high sulfate concentrations within a period of two weeks, however, there is no evidence to show that infants have the same capability.

Thus, the naturally occurring concentrations of constituents in groundwater at Linde preclude its use without treatment. This is consistent with the findings of earlier reports for Linde and the Tonawanda area and the 1995 US Geological Survey (USGS) *Groundwater Atlas for the Lake Erie – Niagara River Basin* (USGS 1995).

The USEPA notes at its web site (http://www.epa.gov/safewater/consumer/2ndstandards.html) (USEPA 2005) that "Non-conventional treatments like *distillation, reverse osmosis* and *electrodialysis* are effective for removal of chloride, nitrates, total dissolved solids and other inorganic substances. However, these are fairly expensive technologies and may be impractical for smaller systems."

Removal of the background (or natural) chemicals in the groundwater at the Linde Site using these methods would also remove any of the FUSRAP eligible COCs from the groundwater. Thus, the 4th element necessary for exposure (a route for human exposure) is missing because the FUSRAP eligible COCs would be removed in any case where drinking water was contemplated. As a practical matter, use of this water for drinking is not reasonable since treatment costs are high and a more than ample supply of fresh water exists in Tonawanda since the source of supply in this area is the Niagara River. Therefore, USACE concludes that there is no current or future completed drinking water exposure pathway for groundwater at Linde.

5.2 Irrigation Water

USACE also considered the possibility that groundwater at the Site would be used for irrigation of edible produce. As in the case of the consideration of drinking water, the potential that groundwater could be pumped to surface for irrigation exists. Because of the naturally occurring levels of salts in the groundwater, however, the continued use of this water without treatment is not reasonable. "The critical concentration [of dissolved salts] in the irrigation water depends on many factors; amounts in excess of 700 mg/liter are harmful to some plants, and more than 2000 mg/liter of dissolved salts is injurious to almost all crops." (Linsley and Franzini 1979). Continued use of saline waters for irrigation may also ultimately impact the viability of a soil to support crops and may also impact the infiltration rate of soils (Keonig and Isaman 1997).

The natural background concentrations of these constituents (salts) in groundwater at Linde would preclude continued use for irrigation without treatment. As a practical matter, use of this water for irrigation is not reasonable since treatment costs are high and a more than ample supply of fresh water exists in Tonawanda since the source of supply in this area is the Niagara River. Therefore, USACE concludes that there is no current or future completed irrigation water exposure pathway for groundwater at Linde.

6. CONCLUSIONS

In assessing whether CERCLA action is warranted for groundwater at Linde, USACE considered the two threshold criteria for remedy selection established in CERCLA Section 121, and described in the NCP at 40 CFR 300.430(f)(l)(i)(A), protection of human health and the environment and compliance with ARARs. USACE also addressed the requirement in NCP Section 300.430(e)(6) that the No Action alternative be considered in CERCLA decisions. Because there is no exposure pathway to a human or environmental receptor for any FUSRAP COC in the affected groundwater, the No Action alternative is protective. There are no ARARs for the groundwater at this site because the water is not and will not become suitable for drinking water, so the second threshold criterion is satisfied. Therefore, the No Action alternative is appropriate, and the conclusion is that no CERCLA action is warranted for the FUSRAP Groundwater OU at the Linde Site.

7. COMMUNITY ROLE IN SELECTION PROCESS

Public input is encouraged by USACE and no final decision will be made on Linde groundwater until all comments are considered.
The administrative record file contains all of the documentation used to support the preferred remedy, and is available at the following locations:

USACE FUSRAP Public Information Center
1776 Niagara Street
Buffalo, NY 14207

Tonawanda Public Library
333 Main Street
Tonawanda, NY 14150

The public is encouraged to review and comment on this Proposed Plan and the supporting Feasibility Study and Addendum to the Feasibility Study. Members of the public who wish to comment on this Proposed Plan may submit their comments in writing to USACE at the following address:

U.S. Army Corps of Engineers
Buffalo District
FUSRAP Public Information Center
1776 Niagara Street
Buffalo, NY 14207-3199

Please refer to this Proposed Plan or to the Groundwater OU, Linde Site, in any comments.

Comments on the Proposed Plan for the Groundwater OU Linde Site will be accepted for 30 days following issuance of the Proposed Plan in accordance with CERCLA, as amended, and the NCP. A public meeting will be held during the comment period to receive any verbal comments the public wishes to make. The public may submit written comments regarding the preferred remedy at the public meeting or by mail during the 30-day comment period.

8. REFERENCES

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DOE 1993b. *Feasibility Study for the Tonawanda Site.* U.S. Department of Energy. November.

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USEPA 2005. http://www.epa.gov/safewater/consumer/2ndstandards.html

USGS 1995. *Ground Water Atlas of the United States, Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont, Carbonate-rock Aquifers, Lake Erie – Niagara River Basin.* HA 730-M. U.S. Geological Survey. 1995.

FIGURES

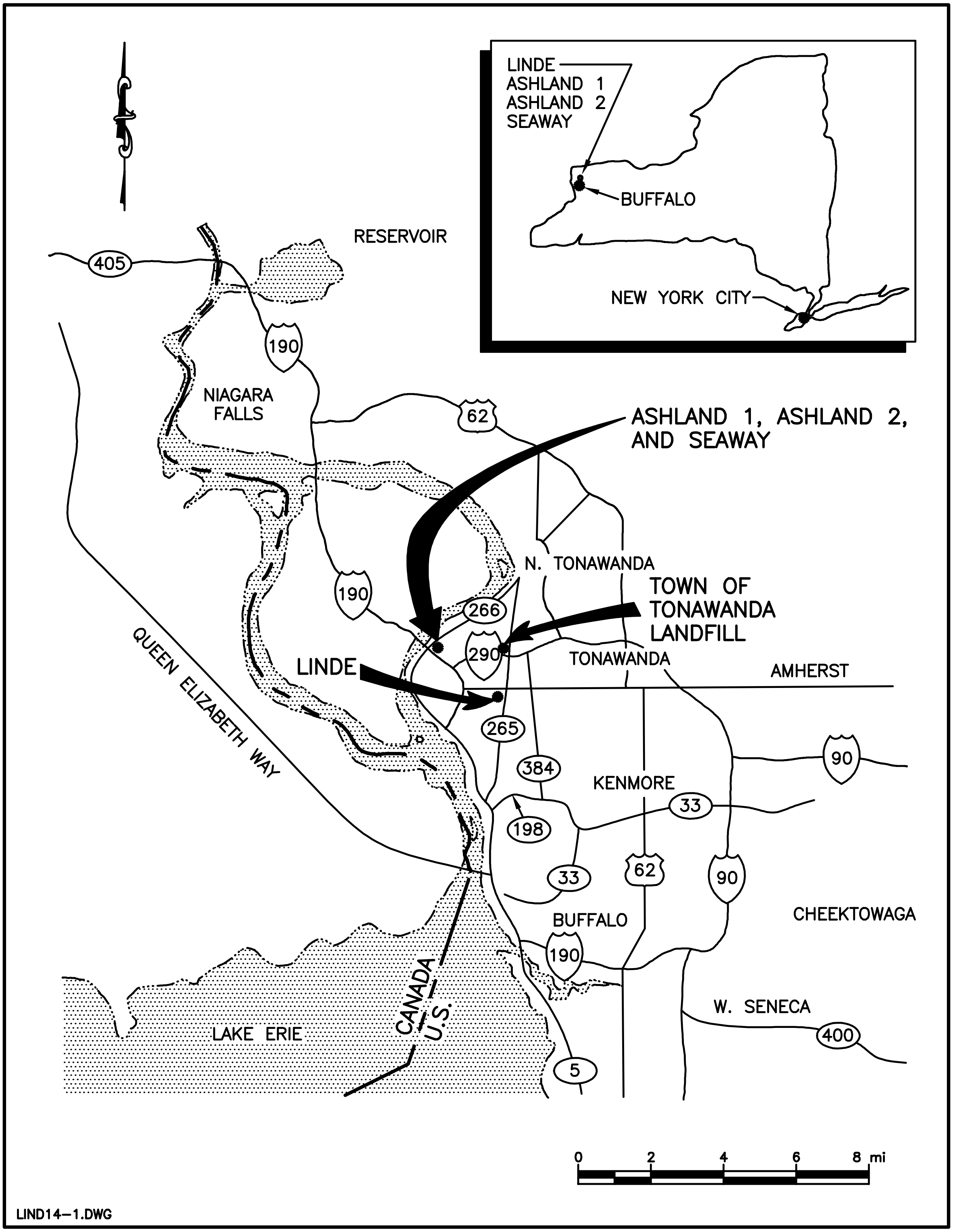

FIGURE 1

REGIONAL LOCATION OF THE TOWN OF TONAWANDA, NEW YORK AND THE ASHLAND 1, ASHLAND 2, SEAWAY, LINDE AND THE TOWN OF TONAWANDA LANDFILL SITES

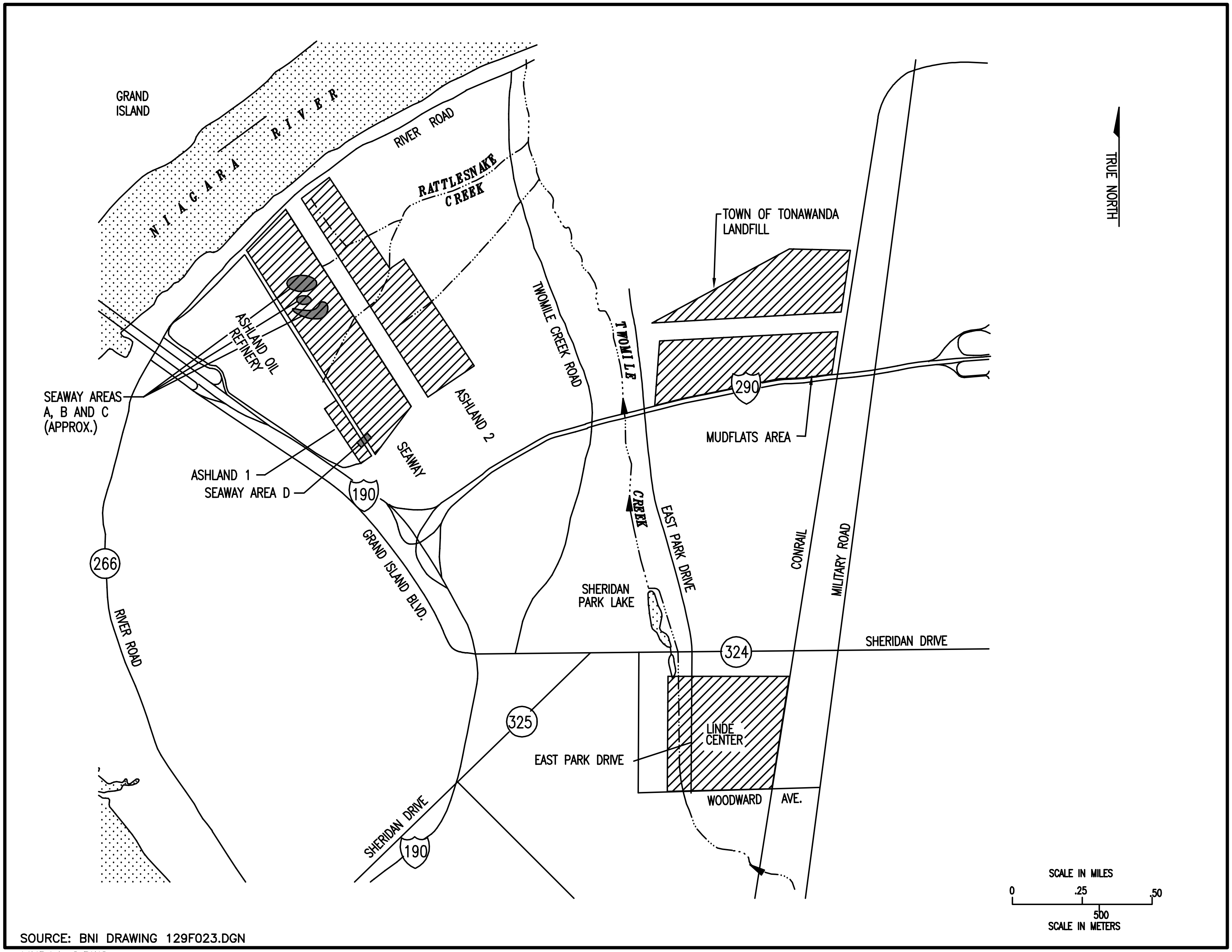

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FIGURE 2
LOCATIONS OF ASHLAND 1, ASHLAND 2,
SEAWAY, LINDE AND THE TOWN OF TONAWANDA LANDFILL SITES

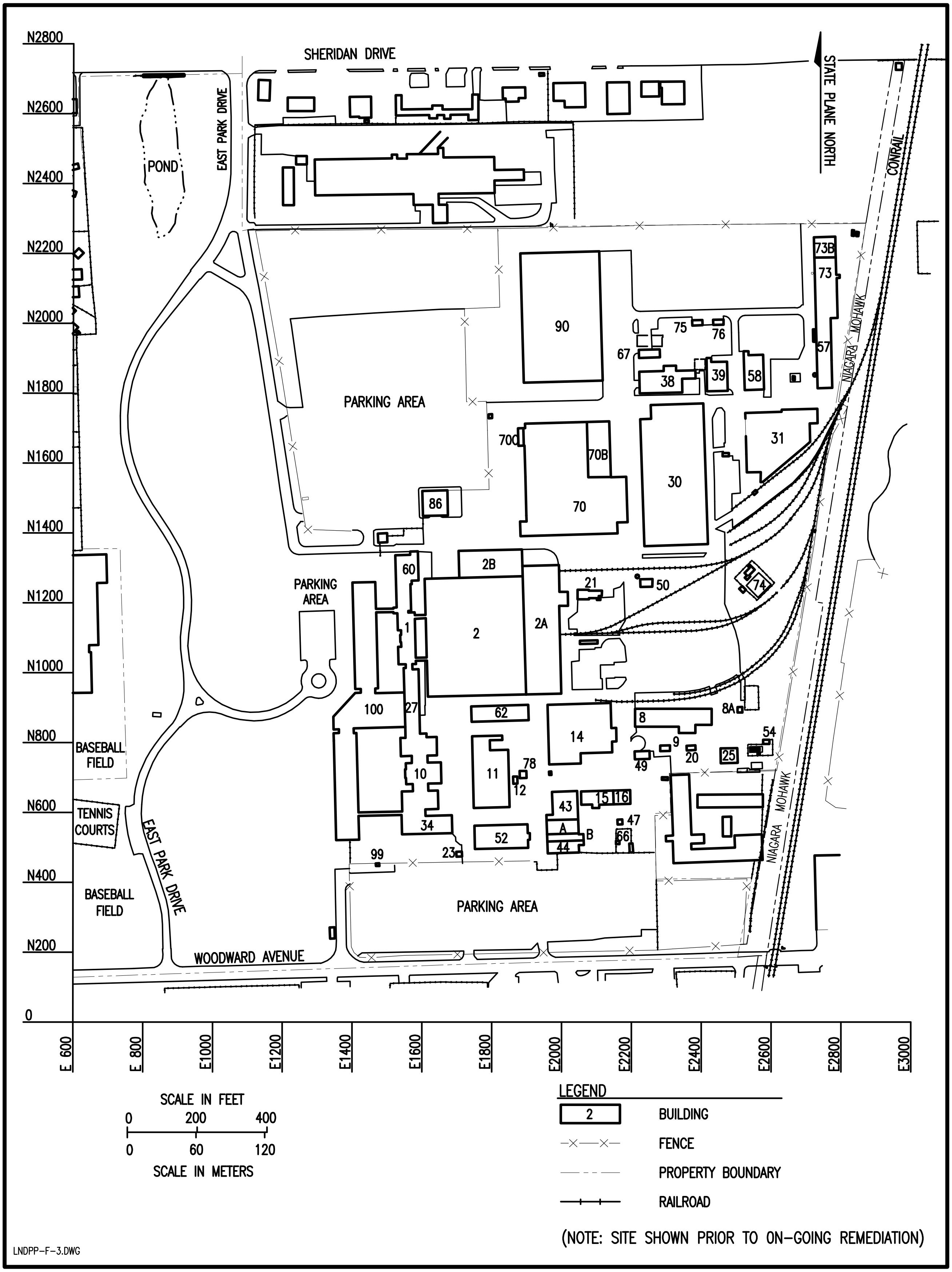


FIGURE 3

LINDE SITE LOCATIONS

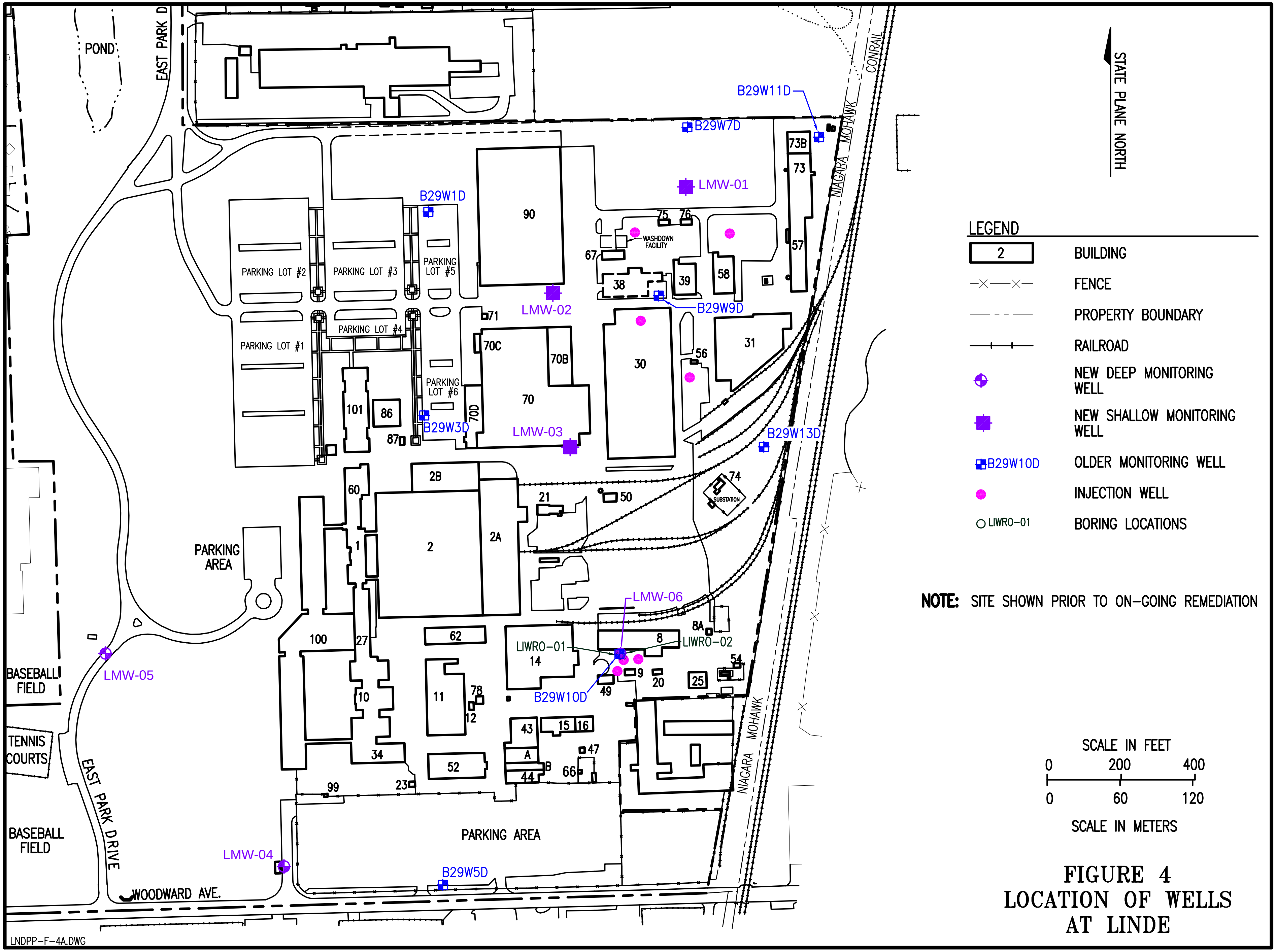


FIGURE 4
LOCATION OF WELLS AT LINDE

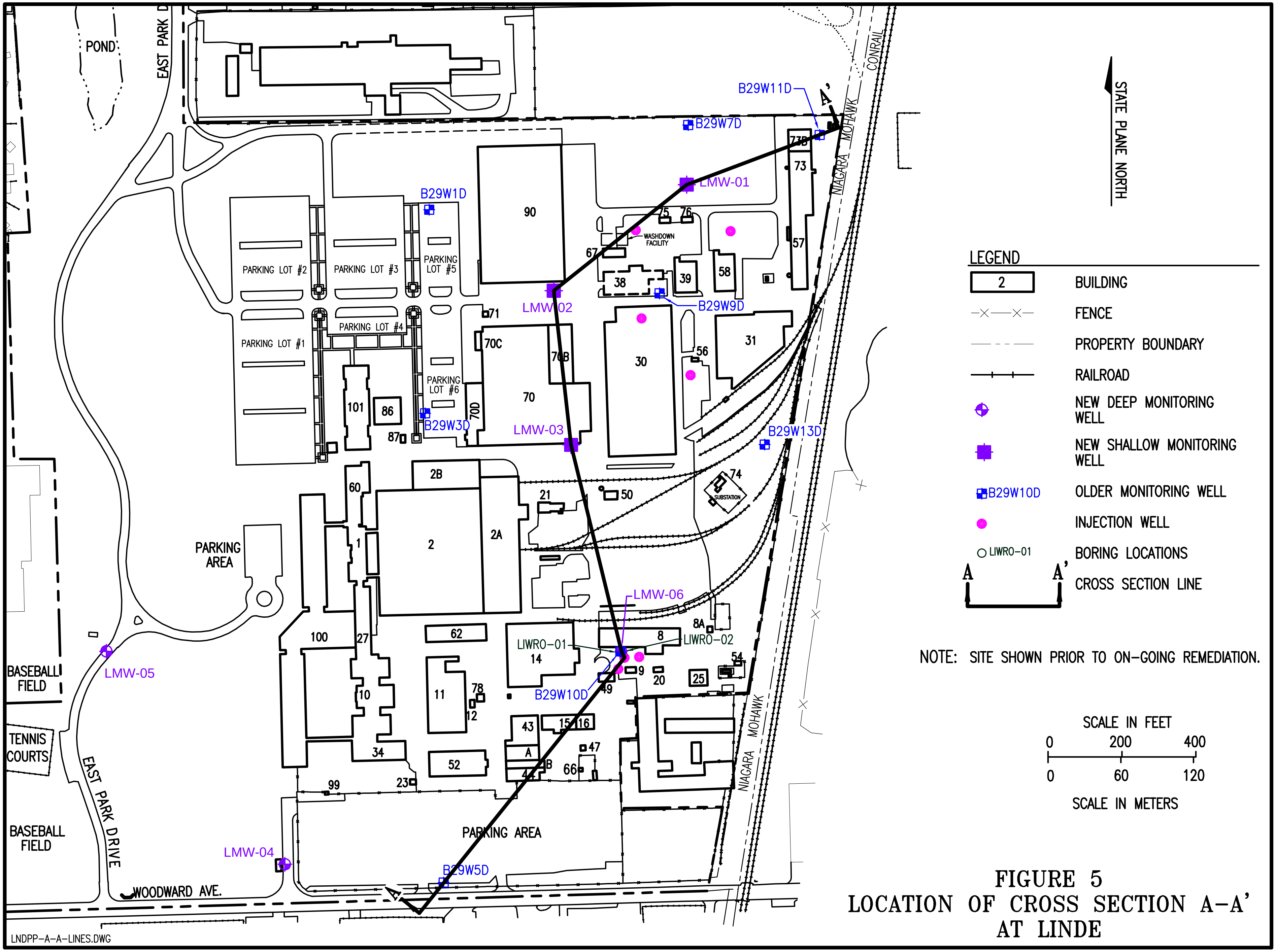
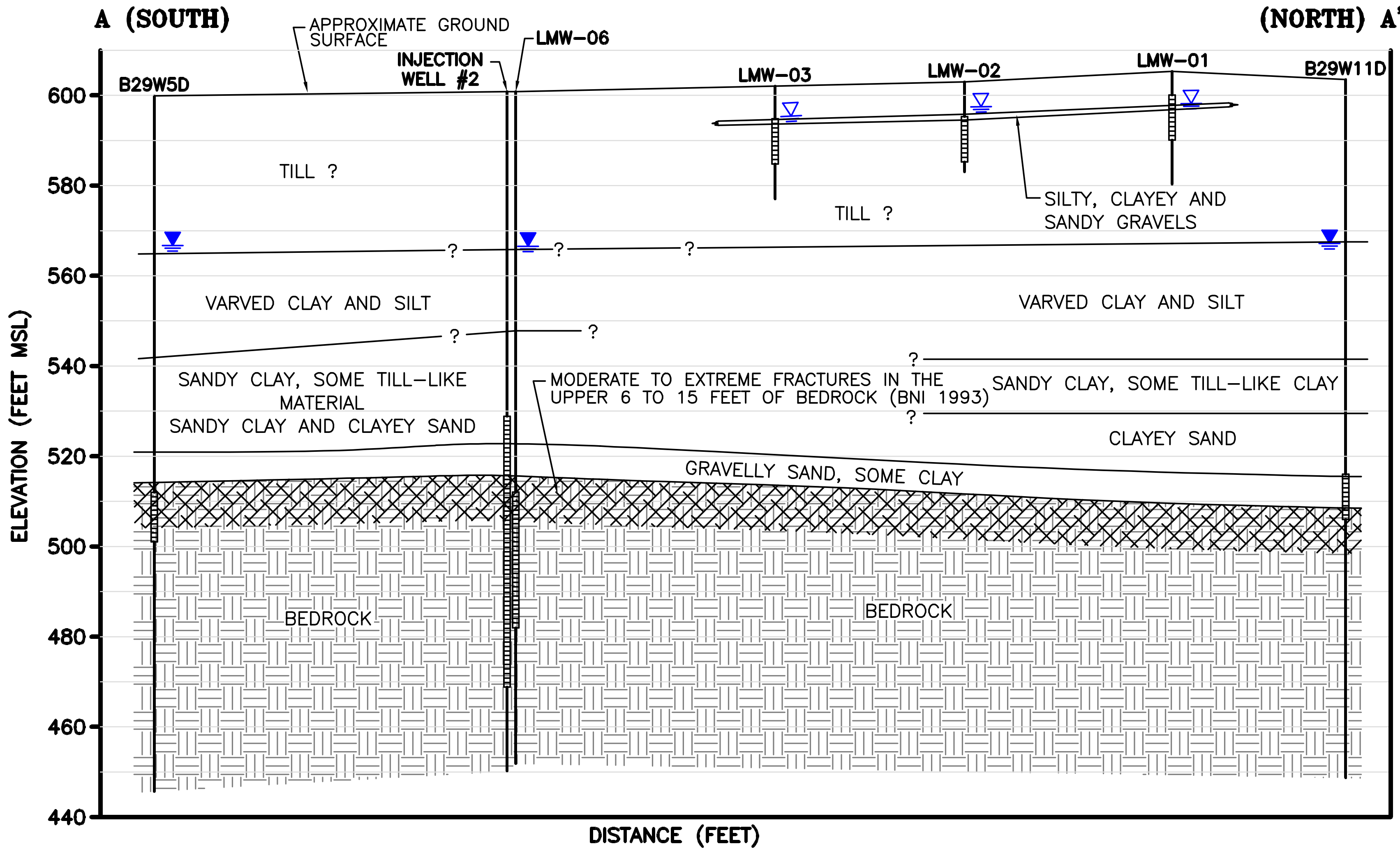
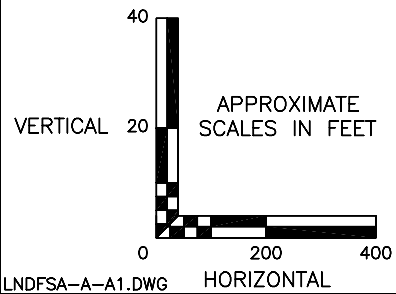


FIGURE 5
LOCATION OF CROSS SECTION A–A'
AT LINDE





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LEGEND

PIEZOMETRIC SURFACE, SHALLOW ZONE AQUIFER, JUNE 18 THROUGH JUNE 20, 2001

PIEZOMETRIC SURFACE, CONTACT ZONE AQUIFER, JUNE 19 AND JUNE 20, 2001

NOTES:

1. SOURCE OF GEOLOGIC DATA (EXCEPT FOR WELLS LMW-01, LMW-02, LMW-03 AND LMW-06) FIGURE 3-29, BNI 1993.
2. ARTIFICIAL FILL ENCOUNTERED ACROSS THE LINDE SITE IN OTHER BORINGS AT DEPTHS RANGING FROM 0 TO 17 FEET BELOW GROUND SURFACE (BNI 1993).

FIGURE 6
CROSS SECTION A-A'
AT LINDE

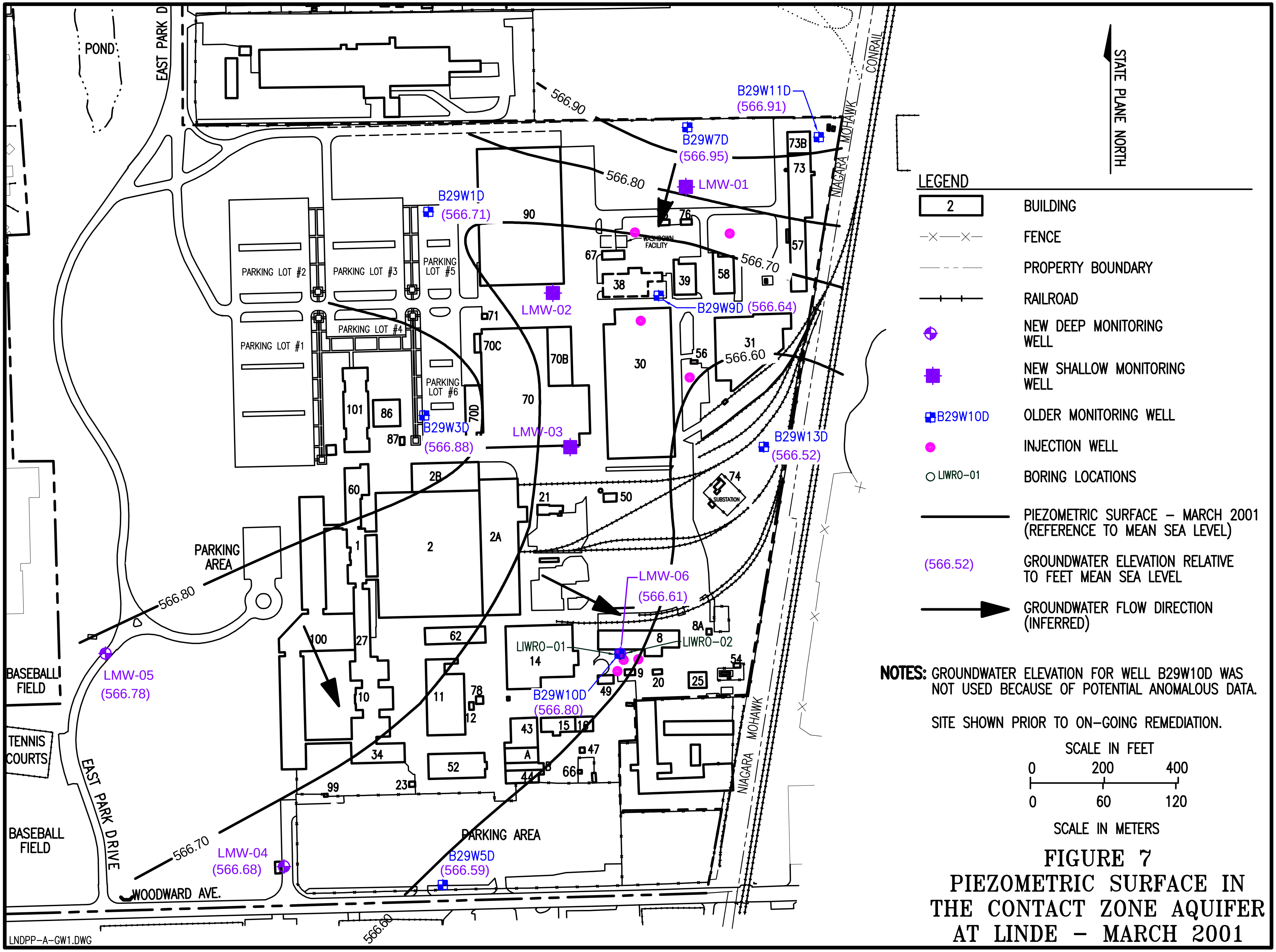

FIGURE 7
PIEZOMETRIC SURFACE IN THE CONTACT ZONE AQUIFER AT LINDE – MARCH 2001

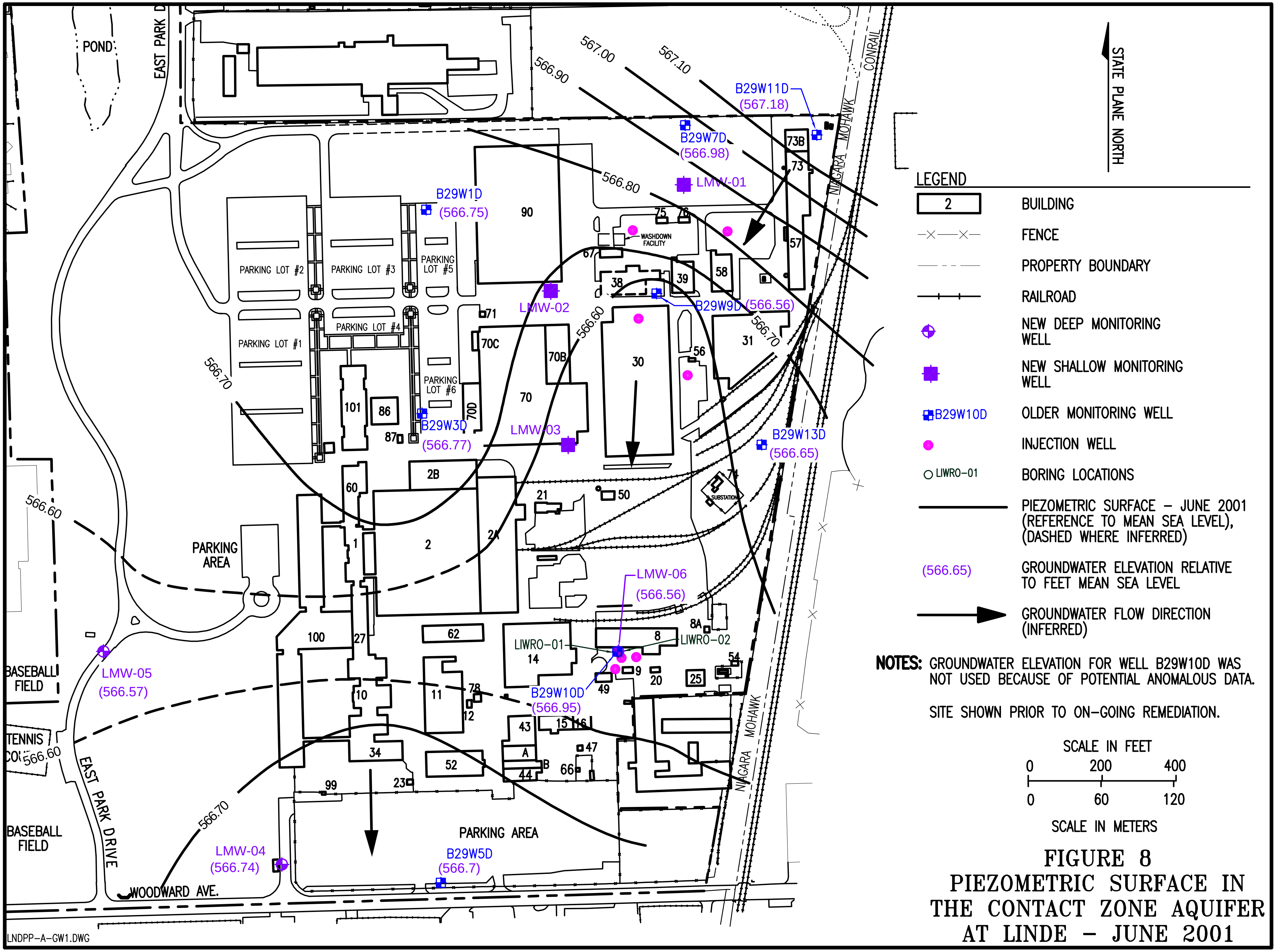

FIGURE 8
PIEZOMETRIC SURFACE IN THE CONTACT ZONE AQUIFER AT LINDE – JUNE 2001

TABLES

Table 1 - Sampling Results
Unfiltered and Filtered Samples From Deep Wells
Total Uranium

UNFILTERED	**Total Uranium**					
Units	µg/L	Qual	µg/L	Qual	µg/L	Qual
WELL	**March 2001**		**June 2001**		**August 2002**	
B29W01D	1.48		0.3		N/A	N/A
B29W03D	1.23		0.27		N/A	N/A
B29W05D	1.43		0.34		0.106	U
B29W07D	0.21		1.56		0.731	
B29W07D (DUP)	0.19		1.81		N/A	N/A
B29W09D	2.16		1.28		1.06	
B29W09D (DUP)	2.36		N/A	N/A	N/A	N/A
B29W10D	765		24.8		N/A	N/A
B29W11D	0.18		0.31		N/A	N/A
B29W13D	0.23		0.53		N/A	N/A
LMW-04	29		6.92		8.53	
LMW-04 (DUP)	N/A	N/A	6.23		N/A	N/A
LMW-05	26.6		8.9		9.04	
LMW-06	837		17.9		98.8	
LMW-06 (DUP)	N/A	N/A	N/A	N/A	97.2	

FILTERED	**Total Uranium**					
Units	µg/L	Qual	µg/L	Qual	µg/L	Qual
WELL	**March 2001**		**June 2001**		**August 2002**	
B29W01D	0.27		0.19		N/A	N/A
B29W03D	1.84		0.4		N/A	N/A
B29W05D	0.52		0.08		0.166	U
B29W07D	0.07		0.04		0.361	
B29W07D (DUP)	0.09		0.05		N/A	N/A
B29W09D	1.83		0.45		0.63	
B29W09D (DUP)	1.92		N/A	N/A	N/A	N/A
B29W10D	470		3.63		N/A	N/A
B29W11D	0.28		0.19		N/A	N/A
B29W13D	0.12		0.16		N/A	N/A
LMW-04	27.3		5.34		8.2	
LMW-04 (DUP)	N/A	N/A	6.39		N/A	N/A
LMW-05	18.1		6.73		7.79	
LMW-06	390		0.24		58.8	
LMW-06 (DUP)	N/A	N/A	N/A	N/A	62.9	

N/A means not applicable, sample was not collected for the date indicated.
Qual = Data qualifier included in report from the laboratory.
U means the result is less than the sample specific minimum detectable concentration

Table 2 - Sampling Results
Unfiltered and Filtered Samples From Deep Wells
Ra - 226 and Ra - 228

UNFILTERED	**Ra-226**						**Ra-228**					
Units	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual
WELL	**March 2001**		**June 2001**		**August 2002**		**March 2001**		**June 2001**		**August 2002**	
B29W01D	0.723		0.637		N/A	N/A	1.8	J	1.53		N/A	N/A
B29W03D	1.23		0.854		N/A	N/A	2.07		-1.29	U	N/A	N/A
B29W05D	0.313	U	1.44		0.29	LT	1.01		0.68		1.06	
B29W07D	1.12		1.28		0.28	LT	0.2	J	1.7		0.84	LT
B29W07D (DUP)	0.309	U	1.05		N/A	N/A	0.59	J	1.37		N/A	N/A
B29W09D	0.509		0.51		0.19	Y1	0.71	J	1.35		1.12	
B29W09D (DUP)	0.637		N/A	N/A	N/A	N/A	0.8	J	N/A	N/A	N/A	N/A
B29W10D	2.69		0.35	U	N/A	N/A	-1	J	0.18		N/A	N/A
B29W11D	1.19		1.21		N/A	N/A	0.79	J	0.76		N/A	N/A
B29W13D	0.911		1.11		N/A	N/A	0.02	J	0.51		N/A	N/A
LMW-04	0.925		0.556	U	0.17		0.44	J	0.4		1.3	
LMW-04 (DUP)	N/A	N/A	0.373	U	N/A	N/A	N/A	N/A	-0.04		N/A	N/A
LMW-05	0.879		0.793		0.9	LT	4.5	J	3.6		1.28	
LMW-06	66.4		0.584		0.6	LT	3.6	J	1.99		1.38	
LMW-06 (DUP)	N/A	N/A	N/A	N/A	0.79	LT,Y1	N/A	N/A	N/A	N/A	1.38	

FILTERED	**Ra-226**						**Ra-228**					
Units	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual
WELL	**March 2001**		**June 2001**		**August 2002**		**March 2001**		**June 2001**		**August 2002**	
B29W01D	0.453		0.52		N/A	N/A	0.62		0.25		N/A	N/A
B29W03D	1.4		1		N/A	N/A	1.38		2.14		N/A	N/A
B29W05D	0.533	U	0.55		0.24	LT	1.24		0.41		1.51	
B29W07D	0.426		0.448	U	0.09	U,Y1	0.98		0.39		1.42	
B29W07D (DUP)	0.279	U	0.558		N/A	N/A	0.58	J	0.63		N/A	N/A
B29W09D	1.03	U	0.529		0.3	LT	1.36		0.62		1.1	
B29W09D (DUP)	0.586		N/A	N/A	N/A	N/A	0.46	J	N/A	N/A	N/A	N/A
B29W10D	3.03		0.799		N/A	N/A	0.74	J	0.34		N/A	N/A
B29W11D	0.682		1.21		N/A	N/A	0.74	J	0.7		N/A	N/A
B29W13D	0.699		1.21		N/A	N/A	0.46	J	0.21		N/A	N/A
LMW-04	0.567		1.03		0.17		0.22	J	0.99		0.57	U
LMW-04 (DUP)	N/A	N/A	0.621		N/A	N/A	N/A	N/A	0.47		N/A	N/A
LMW-05	1.34		0.807		0.75	LT	0.93		0.21		0.47	U
LMW-06	1.34		1.01		0.69	LT,Y1	0.37	J	0.41		0.96	LT
LMW-06 (DUP)	N/A	N/A	N/A	N/A	0.57	LT,Y1	N/A	N/A	N/A	N/A	0.75	LT

N/A means not applicable, sample was not collected for the date indicated.
Qual = Data qualifier included in report from the laboratory.
U means the result is less than the sample specific minimum detectable concentration (MDC).
LT means the result is less than the requested MDC, but greater than the sample specific MDC.
Y1 means the chemical yield in control at 100-110%. Quantitative yield is assumed.
B means analyte concentration is greater than the Instrument Detection Limit (IDL), but less than the required reportable quantity.
DV Qual = Data qualifier determined during data validation by SAIC.

Table 3 - Sampling Results
Unfiltered and Filtered Samples From Deep Wells
Th - 232 and Th - 230

UNFILTERED	**Th-232**						**Th-230**					
Units	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual
WELL	**March 2001**		**June 2001**		**August 2002**		**March 2001**		**June 2001**		**August 2002**	
B29W01D	0.38		0.032	U	N/A	N/A	0.63		0.36	LT	N/A	N/A
B29W03D	-0.003	U	-0.015	U	N/A	N/A	0.078	U	0.41	LT	N/A	N/A
B29W05D	0.09	U	0.007	U	0.019	U	0.52		0.098	LT	0.17	LT
B29W07D	-0.003	U	0.14		0.064		0.074	U	0.68	LT	0.43	LT
B29W07D (DUP)	0.034	U	0.174	LT	N/A	N/A	0.27		0.333	LT	N/A	N/A
B29W09D	0.034	U	0.119	LT	0.022	U	0.077	U	0.53	LT	0.22	LT
B29W09D (DUP)	0.003	U	N/A	N/A	N/A	N/A	0.097	U	N/A	N/A	N/A	N/A
B29W10D	0.51		0.019		N/A	N/A	8.1		0.154	LT	N/A	N/A
B29W11D	-0.01	U	0.071		N/A	N/A	0.3		0.49	LT	N/A	N/A
B29W13D	0.03	U	0.125	LT	N/A	N/A	0.03	U	0.41	LT	N/A	N/A
LMW-04	0.06	U	0.014		0.047	U	0.29	U	0.031	LT	0.109	
LMW-04 (DUP)	N/A	N/A	0.007	U	N/A	N/A	N/A	N/A	0.036		N/A	N/A
LMW-05	0.81		0.83		0.15	LT	1.21		1.8		0.29	LT
LMW-06	0.34	U	0.061	U	0.018	U	6.8		0.49	LT	0.18	LT
LMW-06 (DUP)	N/A	N/A	N/A	N/A	0.021	U	N/A	N/A	N/A	N/A	0.16	LT

FILTERED	**Th-232**						**Th-230**					
Units	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual	pCi/L	Qual
WELL	**March 2001**		**June 2001**		**August 2002**		**March 2001**		**June 2001**		**August 2002**	
B29W01D	-0.02	U	0.14	U	N/A	N/A	0.22		0.02		N/A	N/A
B29W03D	0.022	U	0.003		N/A	N/A	0.15		0.033	LT	N/A	N/A
B29W05D	-0.02	U	0.0083	LT	0.016	U	0.14		0.069	LT	0.17	LT
B29W07D	-0.004	U	0.005	U	0.076		-0.011	U	0.092	LT	0.12	
B29W07D (DUP)	-0.023	U	-0.009	U	N/A	N/A	0.135		0.05	LT	N/A	N/A
B29W09D	0.009	U	0.007	U	0.056	U	0.077	U	0.039	LT	0.22	LT
B29W09D (DUP)	-0.003	U	N/A	N/A	N/A	N/A	0.146		N/A	N/A	N/A	N/A
B29W10D	-0.013	U	0.004	U	N/A	N/A	0.12	U	0.089	LT	N/A	N/A
B29W11D	0.03	U	0.016		N/A	N/A	0.34	U	0.07	LT	N/A	N/A
B29W13D	-0.04	U	0.003	U	N/A	N/A	0.19	U	0.034	LT	N/A	N/A
LMW-04	-0.07	U	0.006	U	0.025	U	0.14	U	0.018		0.21	LT
LMW-04 (DUP)	N/A	N/A	0.014		N/A	N/A	N/A	N/A	0.03	LT	N/A	N/A
LMW-05	-0.021	U	0.021		0.079		0.12	U	0.026		0.077	
LMW-06	0.08	U	0.0057		0.066	LT	0.76		0.037		0.41	LT
LMW-06 (DUP)	N/A	N/A	N/A	N/A	0.019	U	N/A	N/A	N/A	N/A	0.15	LT

N/A means not applicable, sample was not collected for the date indicated.
Qual = Data qualifier included in report from the laboratory.
U means the result is less than the sample specific minimum detectable concentration (MDC).
LT means the result is less than the requested MDC, but greater than the sample specific MDC.
Y1 means the chemical yield in control at 100-110%. Quantitative yield is assumed.
B means analyte concentration is greater than the Instrument Detection Limit (IDL), but less than the required reportable quantity.
J means the results is estimated.

Table 4 - Sampling Results
Unfiltered and Filtered Samples from Deep Wells
Molybdenum

Unfiltered	Mar-01	Jun-01	Aug-02
Well Number	ug/L	ug/L	ug/L
B29W01D			NS
B29W03D			NS
B29W05D			
B29W07D	45	29	33
B29W07D (DUP)	48	33	NS
B29W09D	430	420	330
B29W09D (DUP)	440	NS	NS
B29W10D	250	220	NS
B29W11D			NS
B29W13D			NS
LMW-04		7	4
LMW-05			
LMW-06	370	150	270
LMW-06 (DUP)			270

Filtered	Mar-01	Jun-01	Aug-02
Well Number	ug/L	ug/L	ug/L
B29W01D			NS
B29W03D			NS
B29W05D	8		
B29W07D	46	31	36
B29W07D (DUP)	53	32	NS
B29W09D	420	420	340
B29W09D (DUP)	450	NS	NS
B29W10D	240	200	NS
B29W11D			NS
B29W13D			
LMW-04	21	4	
LMW-05			
LMW-06	370	150	240
LMW-06 (DUP)	NS	NS	240

Note: The results are given in ug/L or approximately parts per billion (ppb)
NS = Not sampled or not analyzed
Blank cell means not detected

Table 5 - Results of Soils and Leachate Analyses - August 2002 and March 2001 Samples

Matrix	Soil	Cal WET	Mod Cal WET	Soil	Cal WET	Mod Cal WET	Soil	Cal WET	Mod Cal WET	Soil	Cal WET	Mod Cal WET
Analyte	**U-234**	**U-234**	**U-234**	**U-235**	**U-235**	**U-235**	**U-238**	**U-238**	**U-238**	**U-TOT***	**U-TOT***	**U-TOT***
Units	**pCi/g**	**pCi/L**	**pCi/L**	**pCi/g**	**pCi/L**	**pCi/L**	**pCi/g**	**pCi/L**	**pCi/L**	**pCi/g**	**pCi/L**	**pCi/L**
Location												
August 2002 Samples												
Class 1 (Building 30 Post Remediation)	0.81	9.5	0.24	0.08	1.06	0.13	0.78	7.4	0.112	1.67	17.96	0.48
Class 1 (Building 30 Post Remediation) (Duplicate of above)	0.93	8	0.19	0.06	0.46	0.09	0.87	7.7	0.1	1.86	16.16	0.38
Class 1 (Building 30 Post Remediation)	0.84	9.5	0.09	0.06	0.53	0.034	0.80	7.7	0.049	1.70	17.73	0.17
Class 2	11.00	662	80	1.38	57	7.4	10.70	633	66	23.08	1352.00	153.40
Class 2	0.91	14.9	0.2	0.06	1.14	0.13	0.91	12.9	0.22	1.88	28.94	0.55
March 2001 Samples												
Bldg 30 Footprint	4,940	123,000	NA	228	7,000	NA	4,690	125,000	NA	9,858	255,000	NA
Bldg 30 Footprint	5,170	124,000	NA	291	7,300	NA	5,450	123,000	NA	10,911	254,300	NA
Bldg 30 Footprint	90	3,210	NA	4.19	195	NA	91	3,190	NA	185.19	6,595	NA
Bldg 73B Excavation	2.36	16.4	NA	0.18	0.83	NA	2.38	13.4	NA	4.92	30.63	NA
Bldg 73B Excavation	3.55	43	NA	0.21	1.9	NA	3.8	42.2	NA	7.56	87.1	NA
Bldg 73B Excavation	27.8	404	NA	2.55	16	NA	28.1	398	NA	58.45	818	NA

Matrix	Soil	Cal WET	Mod Cal WET	Soil	Cal WET	Mod Cal WET	Soil	Cal WET	Mod Cal WET	Soil	Cal WET	Mod Cal WET
Analyte	**Ra-226**	**Ra-226**	**Ra-226**	**Ra-228**	**Ra-228**	**Ra-228**	**Ra-226 + Ra-228**	**Ra-226 + Ra-228**	**Ra-226 + Ra-228**	**Th-230**	**Th-230**	**Th-230**
Units	**pCi/g**	**pCi/L**	**pCi/L**	**pCi/g**	**pCi/L**	**pCi/L**	**pCi/g**	**pCi/L**	**pCi/L**	**pCi/g**	**pCi/L**	**pCi/L**
Location												
August 2002 Samples												
Class 1 (Building 30 Post Remediation)	1.18	15.4	0.02	0.76	19.1	0.04	1.94	34.50	0.06	0.88	14.5	0.36
Class 1 (Building 30 Post Remediation) (Duplicate of above)	1.02	15.9	0.03	0.87	21.9	-0.05	1.89	37.80	-0.02	0.92	14.5	0.31
Class 1 (Building 30 Post Remediation)	1.33	17.4	0.05	0.82	21.6	0.11	2.15	39.00	0.16	1.17	19.6	R
Class 2	2.51	22.2	0.06	1.09	16.4	0.17	3.60	38.60	0.23	2.13	55.1	0.289
Class 2	1.13	12	0	0.74	18.8	0.34	1.87	30.80	0.34	1.01	R	R
March 2001 Samples												
Bldg 30 Footprint	15.4	49.1	NA	2.05	0.17	NA	17.45	49.27	NA	75	1970	NA
Bldg 30 Footprint	16.7	37	NA	0.69	2.5	NA	17.39	39.50	NA	35.5	1940	NA
Bldg 30 Footprint	4.78	80.9	NA	0.83	2.7	NA	5.61	83.60	NA	4.05	123	NA
Bldg 73B Excavation	2.59	11.7	NA	1.9	8.7	NA	4.49	20.40	NA	2.58	6.66	NA
Bldg 73B Excavation	3.92	29.5	NA	0.72	3.3	NA	4.64	32.80	NA	3.84	68	NA
Bldg 73B Excavation	5.23	68.6	NA	1.31	5.3	NA	6.54	73.90	NA	11	299	NA

Notes:

Class 1 = Areas where active soil remediation (soil removal) has occurred or where active remediation is ongoing. Collected from Building 30 excavation (below slab).

Class 2 = Areas that laterally bound Class 1 areas and contain soils that are not impacted by radioactive materials above the action levels.

Cal WET = Leachate - California Waste Extraction Test. Extraction fluid pH = 5

Mod Cal WET = Leachate - Modified California Waste Extraction Test, performed August 2002 only. Extraction fluid pH = 7.95 (same as the groundwater).

*U-TOT = Σ U-234 + U-235 + U-238

R = Result rejected by during data validation

DUP = Duplicate sample taken

NA = Not applicable, test not conducted for the sample indicated