FUSRAP Groundwater Summary, Analysis, and Recommendations

1.0 Introduction/DOE Policy

The purpose of this document is to provide an overview of issues related to current and potential future ground water contamination at Formerly Utilized Sites Remedial Action Program (FUSRAP) sites. It focused on identifying critical issues related to health risk via groundwater pathways and provides program management strategies and potential remedial techniques that may be considered to mitigate the United States Army Corp of Engineers (USACE) vulnerability that may arise because of the real or perceived threats to ground water quality at FUSRAP sites. Science Application International Corporation (SAIC) wrote this document.

This effort was limited to compiling readily available data and information published in a variety of existing FUSRAP documents. A site-by-site bibliography is provided. It should be recognized that this overview is only a starting point for continued programmatic integration in developing a comprehensive strategy for addressing FUSRAP ground-water issues.

The single most significant concept that has arisen as this document was assembled is that there was no overarching programmatic strategy to be passed to the USACE from Department of Energy (DOE) for addressing FUSRAP groundwater contamination and related issues.

The most significant issues can be divided into the following categories that require better understanding or programmatic clarity:

1) The site and regional hydrogeologic system,
2) the presence, persistence, and transport of contaminants within the site and regional hydrogeochemical setting,
3) determination of the risk associated with current or potential contamination,
4) bounding the potential cost impacts related to the range of potential outcomes resulting from the various courses of action available to the USACE,
5) groundwater technologies, and
6) possible management alternatives.

1.1 FUSRAP Ground Water Approach Under the Department of Energy

The single common feature linking FUSRAP sites together is that they have radioactive contamination on properties that are accessible to the public or to private property owners. Beyond this, the sites begin to diverge from each other. Many sites were brought into FUSRAP because they were sites with Manhattan Engineer District/ Atomic Energy Commission (MED/AEC) activities. However, some notable exceptions exist, including the Hazelwood and Wayne Interim Storage Sites. Further, in addition to radiological contamination, many FUSRAP sites have significant non-radiological contamination in both the soil and ground water.

The DOE approach to ground water on the FUSRAP sites were narrowly focused on radiological contaminants. Ground-water investigations were generally limited to areas in contact with or immediately adjacent to radioactively contaminated soil. This approach generally reflects DOE's interpretation of their congressional mandate, which was that DOE only had the authority to address MED/AEC-related contamination, the bulk of which was radiological. It was not widely recognized that to understand the fate and transport of radionuclides, it is necessary to acquire geologic, hydrologic, and chemical information about the entire ground-water system.

This narrow focus restricted the development of a comprehensive program to address ground water at FUSRAP sites. In most cases, DOE did not evaluate contaminant fate and transport within a regional hydrogeologic setting.

The primary weakness was not to consider the total hydrologic system. That is, no models or monitoring systems have been established where the total hydrologic system is considered or understood. Typically, rainfall was not monitored, run-off was only measured sporadically, there is no data available on infiltration or evapo-transpiration, piezometric measurements on existing wells were made infrequently and inconsistently, and regional ground water flow is only known with a limited, qualitative understanding.

Only cursory descriptions were provided of the regional geology at the sites. At many of the major sites, very little is known about the hydrogeology of the bedrock or deep overburden, even though contaminants may have been detected there.

A similar weakness exists in the understanding of the total geochemical system. Because of the narrow focus on radionuclides and the lack of a hydrogeologic/geochemical model, many important parameters were not measured, even in places where monitoring wells exist. These parameters include Eh, Volatile Organic Compounds (VOCs), Semi-volatile Organic Compounds) (SVOCs), and metals and their oxidation states (including the oxidation states of the radionuclides). These parameters may be measured at some times at some sites. However, they are not collected at frequencies and locations that optimize the understanding of fate and transport at the sites.

Due to the existence of good fate and transport models for the sites being limited, it is difficult to determine the critical frequency and locations for sampling, and the list of analytes that should be regularly measured.

1.2 Implications of Prior Policy on the Program

Since acquiring the program from DOE, the USACE has, in some cases, increased the analysis for non- radiological compounds in ground water. Typically, it has been in reaction to regulatory concerns as site documentation gets driven toward finalization.

However, the ability to maximize the technical and political utility of this information is limited because of the lack of a comprehensive understanding of the hydrogeologic and geochemical systems. This deficiency creates a circumstance where it is not possible to quantitatively predict and bound estimates of contaminant transport to environmental receptors.

The impact of these limitations is to undermine the USACE's ability to make persuasive receptor and risk arguments, especially where remedies could benefit from a passive approach to contaminants in groundwater. When convincing arguments cannot be made to regulators and the public concerning the lack of potential receptor exposure for a passive remedial scenario, the alternative is to implement a conservative, active, and more expensive remedy.

An excellent example of this situation occurred at the St. Louis Airport Site under DOE administration. The regulators and public perceived that Coldwater Creek was potentially threatened by migration of shallow, uranium-laden ground water to the creek. Despite the lack of demonstrated impacts to the creek, DOE could not conclusively show that the creek would not be impacted at some point in the future. The result was that DOE felt it necessary to excavate soil adjacent to the creek and install a "clay plug" which was intended to limit the movement of contaminated ground water toward the creek. This involved the removal of several thousand cubic yards of material and cost over two million dollars.

It is difficult to demonstrate that the plug is having any effect on the transport of contaminated groundwater to the creek for two reasons. First, because the base of the plug was installed at the top of the water surface (at the lowest water surface position) and because there were no demonstrated impacts to the creek prior to installation of the plug. In fact, the plug may have created deleterious effects by aggravating the rise in the water surface during the winter months, forcing contaminated groundwater laterally into the SLAPS ditches where it required treatment and raising pore pressures on the excavation side slopes causing slope failures on excavation surfaces.

In lieu of an adequately characterized and understood contaminant transport system, it was deemed necessary to pursue the plug resulting in additional project cost and, perhaps, other deleterious effects to the project.

1.3 Structure of this Overview

This overview report works within the constraints imposed by the current status of ground water information available on FUSRAP. The primary effort has been to collect as much existing information as possible from across the program, organize and synopsize that information so that programmatic decision makers can effectively focus their resources on the most critical components of a successful programmatic ground water strategy.

To that end, the remainder of this report is divided into six major sections.

Section 2 surveys the FUSRAP sites and identifies those that are likely to be affected by ground water issues.

Section 3 summarizes the existing hydrogeologic and contaminant information available for the sites identified in Section 2.

Section 4 identifies the important ground water resources (and pathways) that may be impacted by site contaminants and, where available, provides the regulatory perspectives on the potential exposure of receptors.

Section 5 discusses some promising remedial technologies, other than pump and treat, that may be effective in mitigation transport of contaminants to potential receptors on FUSRAP sites.

Section 6 provides recommendations that program and site managers might use to minimize the impact of ground water related issues on the program.

Section 7 provides bounding estimates on the costs associated with necessary characterization of the ground water on each site.

Section 8 provides recommendations for future work.

All figures follow the bibliography.

2.0 FUSRAP Sites with a Possible Groundwater Remedial Component

Figure 2.1 shows the locations of the FUSRAP sites with potential ground water remedial components. The sites follow:

St. Louis Sites
- St. Louis Downtown Site (SLDS) and its associated vicinity properties (VPs)
- North County Sites: Including the St. Louis Airport Site (SLAPS), Hazelwood Interim Storage Site (HISS), and Vicinity Properties (VPs)

New York District
- Wayne Interim Storage Site (WISS)
- Maywood Interim Storage Site (MISS)
- Middlesex Sampling Plant (MSP)

Buffalo
- Tonawanda Sites
  - Ashland 1 and 2
  - Linde
  - Seaway Industrial Park
  - Niagara Falls Storage Site (NFSS)
- Ohio
  - Luckey
  - Painesville

Baltimore
- Colonie Interim Storage Site (CISS)
- Shpack Landfill
- W.R. Grace

New England
- Combustion Engineering (CE)

Philadelphia
- DuPont Chamber Works

3.0 Characterization of Sites

For section 3, each site has a separate numeric designation. For instance, the section on site characterization for the St. Louis Downtown Site is SLDS 3.0 Site Characterization. A table of USEPA Maximum Contaminant Levels (MCLs) for compounds in drinking water is provided at the end of the document.

SLDS

SLDS 3.0 Site Characterization

The St. Louis Downtown Site (SLDS) and its Vicinity Properties (VPs) are composed of a 45-acre industrial property in the eastern section of St. Louis. During the time period of 1942 through 1957 radium and uranium were extracted from ore at the Mallinckrodt Chemical Plant under contract with Manhattan Engineering District (MED) and Atomic Energy Commission (AEC). In 1977 a site characterization study was performed and radioactive concentrations were found to exceed Department of Energy (DOEs) guidelines, it was decided that further characterization of the site was necessary. Since then, approximately 19,600 yd^3 of contaminated soil has been shipped off-site and 8,000 yd^3 has been stockpiled on-site.

"In October 1998, United States Environmental Protection Agency (USEPA) Region VII and the United States Army Corp of Engineers (USACE) signed the Record of Decision (ROD) for the SLDS (USACE 1998c). The ROD addresses contamination related to the historical activities in the accessible soils and ground water. The selected remedy involves excavation of ~ 100,000 yd^3 of accessible soils on the basis of criteria that vary with depth and location and long-term monitoring of the lower B unit aquifer. If long term monitoring of the B Unit shows significant exceedances of the thresholds by the Contaminants of Concern (COCs) specified the ROD a ground water remedial action alternative will be evaluated. Inaccessible soils at SLDS were not addressed in the ROD (USACE 1999)."

SLDS 3.1 Geology and Hydrogeology

A generalized stratigraphic column is presented as SLDS Figure 3.1, below, a general outline of SLDS is given:

Surface fill: Rubble and fill (0-25 feet)
- Brick fragments, reinforced concrete, organic material, coal slag, etc.

Upper Sedimentary Unit: Non-lithified sedimentary deposits
- Clayey silt with interbedded silty clay, clay, silt, and sandy silt
- Laterally contiguous across SLDS (10-30 feet)

Lower Sedimentary Unit: Non-lithified deposits
- Silty sand that grades laterally to a sand toward the Mississippi River
- Unit is present only beneath the eastern portion of the property (0-60 feet)
- Saturated, Mississippi alluvial aquifer

Bedrock Unit: Hard and microcrystalline limestone containing chert.

- Moderately fractured with joints oriented horizontally

The principal aquifer beneath SLDS is the Mississippi River alluvial aquifer. The alluvial aquifer is not currently used for domestic water supply. The State of Missouri contends that it could be used in the future and is therefore classified as a potential source of water for beneficial purposes, USEPA Class IIB (USACE 1998a). The upper portion of the bedrock is also a water-bearing zone with groundwater occurring in secondary porosity features (DOE, 1994).

SLDS 3.2 Substances Detected at the Site Above Background Levels

SLDS 3.2.1 Substances in Soil

The principal radioactive COCs found at the SLDS are Ra-226, Th-230, Th-232, U-238, and their radioactive decay products. Radioactivity ranges in depth from the surface to 23 feet below SLDS. Volatile organic compound (VOC) concentrations are associated with processes other than MED/AEC processes and are generally low across the site (averaging 2 to 13 ppb) with little chance of migration (DOE 1993). Base/Neutral and Acid Extractable (BNAEs) were detected across the site averaging 585 to 14,900 ppb, they exhibit little mobility.

Metals were found in soil above, within, and beneath areas of radioactive contamination. Eighteen metals exceeded background concentrations: antimony, arsenic, barium, boron, cadmium, chromium, cobalt, copper, lead, magnesium, manganese, mercury, molybdenum, selenium, silver, sodium, thallium, and zinc.Only arsenic and cadmium are considered COCs (USACE, 1998a).

Chemical sampling over the area indicates that the waste does not exhibit Resource Conservation and Recovery Act (RCRA)-hazardous waste characteristics for corrosivity, TCLP, ignitability, and reactivity (DOE 1993).

SLDS 3.2.2 Substances in Groundwater

Radiological, organic, and inorganic groundwater constituents were analyzed based on their potential presence in the former ore processing materials or in the former waste at SLDS.

Radionuclides

Various radionuclides and their daughter products are associated with SLDS. The radionuclides Ra-226, Th-230, and total uranium ("total" refers to the combined analyses of uranium isotopes U-234, U-235, and U-238) occur most frequently and were analyzed in ground-water samples collected from eight monitoring wells on a quarterly basis (four collection events) between July 1988 and April 1989. A comprehensive round of sampling was conducted at SLDS in late 1997.

Uranium, radium, thorium, and their decay products have been detected in the fill and upper sediments. However, none of the radionuclides have exceeded their MCL (or proposed MCL in the case of uranium) in the alluvial aquifer.

Metals

Aluminum, arsenic, barium, boron, cadmium, calcium, chromium, copper, iron, magnesium, manganese, nickel, potassium, selenium, sodium, and zinc were all detected at elevated levels at SLDS in the upper sediments and fill during the quarterly sampling from July of 1988 to April of 1989 (BNI 1992). Iron and manganese naturally occur at high levels throughout the overburden.

"Several inorganic constituents exceeding Maximum Contaminant Levels (MCLs) were detected in the 1997/1998 ground-water samples collected from SLDS. Elevated concentrations of inorganic constituents may be caused by the coal ash and cinders in fill material. Of these, dissolved iron and manganese were most prevalent. Iron was detected in 12 of the 17 wells above its Secondary Maximum Contaminant Level (SMCL) (300μg/l), manganese was detected above its SMCL (50 μg/l) in ground water from all wells except well B16W12S (USACE 1998)." Aluminum concentrations exceed its SMCL of 200 g/l in both the upper and lower zones with a maximum concentration of 637 μg/l. Arsenic was only found in excess of its SMCL (50μ g/l) in well B16W06S which is located in the upper zone in the northeast section of SLDS.

Organics

"Ground water at the site was analyzed for EPA Method 8260 priority pollutant Volatile Organic Compounds (VOCs) and EPA Method 8270 semi-volatile organics. Six VOCs and one Semi-volatile Organic Compound (SVOC) were detected above their associated MCLs (USACE 1998)." Pesticides, herbicides, and PCBs were also analyzed. 1,2-dichloroethene, benzene, dichloromethane, vinyl chloride, tetrachloroethene, TCE, and hexachlorobenzene were all found to exceed their MCL.

Benzene, PCE, and TCE were found slightly above their MCLs in both the upper and lower zones. Dichloromethane was isolated to the lower zone. The highest concentrations of 1,2-dichloroethene and vinyl chloride were found near the central portion of SLDS in a well completed in both the upper and lower zones. Other MCL exceedances were limited to the lower zone. Hexachlorobenzene was the only SVOC detected above its MCL and is limited to the lower zone. None of the organics are attributable to MED/AEC activities at the site

Other Inorganics

Chloride concentrations ranging from 297 to 1,240 mg/l were measured in both the upper and lower zones throughout SLDS. Chloride has a SMCL of 250 mg/l. Sulfate concentrations were elevated above its MCL in four wells analyzed in both the lower and upper hydrostratigraphic zone.

SLDS 3.3 Conceptual Ground Water Fate and Transport Model

The fill and upper sedimentary units contain radiological, organic, and inorganic contamination to varying degrees. However, this portion of the saturated zone beneath the SLDS is not a useable source of water. Very little infiltration occurs over this site because it is covered with buildings and impervious surfaces. The silty and clayey sediments of the upper sedimentary unit act as relatively good flow and transport barrier to downward migration of contaminants toward the alluvial aquifer. The potentiometric surface of the upper unit does not appear to directly respond to changes in river stage. The combination of low recharge and fine-grained sediments at the base of the upper sedimentary system make it unlikely that contaminants will migrate in high concentrations to the alluvial aquifer.

Groundwater at SLDS generally flows toward the Mississippi River. Groundwater also discharges from bedrock into the alluvial aquifer. The alluvial aquifer demonstrates a clear, immediate, and predictable response to changes in the river stage. While low levels of non-MED/AEC contamination are present in the alluvial aquifer, it is relatively clean despite over a century of chemical manufacturing. It is likely that exchange of water with the Mississippi River acts to mitigate the possibility that high concentrations of contaminants could persist in the alluvial aquifer for extended periods of time. The presence of naturally occurring iron, manganese, and aluminum would make it necessary to treat water from the alluvial aquifer prior to any sort of beneficial use.

SLDS 3.4 Adequacy of Information

Background data for the groundwater at SLDS are not available. Therefore, it is difficult to know how contaminants with anthropogenic sources compare to background values in a setting that has been exposed to industrial conditions for over 150 years. Little is known about how compounds in the fill may have impacted the alluvial aquifer or bedrock system. The bedrock system has not been characterized.

SLAPS and HISS

SLAPS/HISS 3.0 Site Characterization

The St. Louis Airport Site (SLAPS) consists of 22-acres that was used to store uranium-bearing soil processed at SLDS from 1946 to 1966. In 1996 the contaminated soil was moved to Hazelwood Interim Storage Site (HISS) and Canon City, Colorado. During the waste removal and transferring of material, improper storage, handling, and transportation of these materials caused contamination of the haul routes and vicinity properties. After the contaminated soil was removed from SLAPS, on-site structures were demolished and clean fill was spread over the disposal area. Approximately 27,000 yd^3 of contaminated material was transferred to HISS. In 1982, a radiological characterization of the north and south ditches at SLAPS and portions of Coldwater Creek showed radioactivity levels exceeding DOE guidelines to depths of 18 feet. DOE excavated approximately 46,000 yd^3 of the contaminated soil to support the cities of Hazelwood and Berkeley in a drainage and road improvement project. 8,000 yd^3 more of the soil was stockpiled when Stone Container Corporation expanded its facility. After finding soil exceeding DOE guidelines, a characterization of SLAPS was conducted from 1986 to 1990 (USACE 1998). In 1997, excavation of the eastern bank of Coldwater Creek was completed.

"A Federal Facilities Agreement (FFA) (DOE 1990) was negotiated by the U.S. EPA [Region VII] and DOE in 1990. That agreement describes the process that will be used to remediate all the St. Louis Sites and the lists the responsibility of each agency. Since that time, the FUSRAP program was transferred from DOE to the USACE by the U.S. congress.

The HISS site and Vicinity Properties are on the National Priorities List (NPL); therefore, all the St. Louis Sites will be addressed in accordance with the procedures developed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Values of the National Environmental Policy Act (NEPA) have also been integrated into the process (USACE 1998)."

SLAPS/HISS 3.1 Geology and Hydrogeology

SLAPS and HISS are composed of three main hydrostratigraphic zones, they are described below and outlined in detail on SLAPS/HISS Figure 3.1

Upper Non-lithified Hydrostratigraphic Zone:

Unit 1	Fill and topsoil
Unit 2	Clayey silts, fine sands
Subunit 3T	Silty clay, moist to saturated

Middle Non-lithified Hydrostratigraphic Zone:

- Subunit 3M
- Plastic clay, moist, stiff, highly plastic
- Interpreted as an aquitard
- Ranges in thickness from 0 feet beneath the eastern end of SLAPS up to 26 feet beneath the western part of the site

Lower Non-lithified Hydrostratigraphic Zone:

Subunit 3B	Silty clay
Unit 4	Glacial clayey gravels, sands, and sandy gravels

Bedrock:

- Pennsylvanian Shale - Interbedded silty clay/shale, lignite/coal, sandstone, and siltstone
- Mississippian Limestone

The upper and lower non-lithified hydrostratigraphic zones have little to no communication. The stratigraphic unit, known as Unit 3, is a sequence of glaciolacustrine sediments deposited during the Illinoisan glacial advance. It is comprised of 3 subunits (3T, 3M, 3B for top, middle, and bottom). Unit 3 is entirely composed of clays and silts. It is laterally continuous across the SLAPS and HISS. However, the subunit with the most clay, subnit 3M, is only present where the ancient lake was the deepest. The entire Unit 3 acts as a relatively impermeable barrier to the exchange of groundwater between the upper and lower saturated non-lithified zones.

SLAPS/HISS 3.2 Substances Detected at the Site Above Background Levels

SLAPS/HISS 3.2.1 Substances in Soil

Radiological contamination is found throughout essentially all of SLAPS. In areas, contamination was detected up to 18 feet in depth but the majority of the contamination was between the depths of 4 to 8 feet at SLAPS. Contamination at HISS ranges from surface level to 6 feet below with an average depth of 3 feet. U-238, Ra-226, and Th-230 are the principal radionuclides found throughout HISS and SLAPS.

A number of VOCs exceed the detection limits at SLAPS. Toluene, TCE, trans-1,2-dichloroethene were all found at concentrations exceeding their detection limits, unevenly and distributed at low levels across SLAPS.

Chemical sampling conducted for corrosivity, ignitability, reactivity, and EP-TOX at both HISS and SLAPS indicate that the soil does not exhibit RCRA-hazardous waste characteristics (DOE 1993).

SLAPS/HISS 3.2.2 Substances in Groundwater

Radiological, organic, and inorganic groundwater constituents were analyzed based on their potential presence in the former ore processing materials or generated waste stored at HISS from SLAPS.

Radionuclides

Total uranium, Ac-227, Th-227, Th-228, Th-230, Th-232, Pa-231, Ra-226, Ra-228, and Pb-210 were all identified as analytes of interest and analyzed for their concentration in ground water. Based on historical detection and background exceedances and/or regulatory action levels, Ra-226, Th-230, and total uranium are all considered PCOCs. Radiological contaminants occur only in the shallow hydrostratigraphic zone at the SLAPS and HISS. The highest concentrations are restricted to a small subsurface zone at the western end of the SLAPS that correlates with the position of an abandoned Coldwater Creek meander bend that was buried with waste as MED/AEC began to store waste at the SLAPS.

Metals

Aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, nitrate, potassium, selenium, silver, sodium, vanadium, and zinc were all analyzed for their concentrations in groundwater. Based on their MCL exceedances arsenic, manganese, nickel, nitrate, and selenium were identified as PCOCs in the shallow hydrostratigraphic zone at SLAPS. Elevated arsenic concentrations were found in the lower hydrostratigraphic zone beneath the western part of SLAPS, the western portion of the ball fields, and in the deep wells north of Coldwater Creek (USACE 1998). These concentrations are likely to be naturally occurring since there are no high concentrations in the upper zone. Manganese is a PCOC in both the shallow and deep hydrostratigraphic zone of HISS. Elevated nickel concentrations were detected in wells off-site of SLAPS to the north, south, and west. However, nickel is not considered a PCOC because its presence is not likely to be related to MED/AEC activities on SLAPS. The upper hydrostratigraphic zone of HISS and SLAPS contain concentrations of nitrate and selenium ranging from 11mg/l to 729 mg/l and 81µ/l to 4,360 µg/l respectively. Nitrate concentrations occur in the western portion of SLAPS and along Coldwater Creek. The lower hydrostratigraphic zone shows only trace concentrations of nitrate and selenium. The widespread presence of nitrate and selenium in the upper zone may be related to site activities (USACE1998).

Organics

VOCs and SVOCs were collected and analyzed. TCE was the only VOC found above its MCL at SLAPS. High concentrations of TCE were found only in the upper hydrostratigraphic zone at the western end of the SLAPS and in two wells on the ballfields. The highest concentrations of TCE were found in well B53W017S at the Ballfields during 1990 and 1991. The concentrations were approximately 1400 and 1200 µg/L, respectively. In 1997, the level of TCE in this well dropped to approximately 600 µg/L. There is no indication that natural attenuation or biodegradation of TCE is occurring because only trace amounts of the degradation products of TCE have been detected.

Other Constituents

Tritium concentrations were evaluated at the SLAPS to attempt to determine the degree of separation between the upper and lower non-lithified hydrostratigraphic zones. Samples of tritium taken in the lower zone contain less than 1 pCi/l of tritium while upper zone 10 out of 11 samples taken in the upper hydrostratigraphic zone contained greater than 10 pCi/l of tritium (USACE 1998). This is strong evidence that post-atomic bomb atmospheric tritium has been introduced to the upper hydrostratigraphic system, but not to the lower.

SLAPS/HISS 3.3 Conceptual Ground Water Fate and Transport Model

Contaminants occur in the surficial saturated materials of the SLAPS and HISS. However, because of the geologic setting (i.e., glacio-lacustrine sediments), it is unlikely that migration will occur to deeper saturated zones. None of the non-lithified sediments are a potential source of groundwater for any use because of extremely low yields and poor water quality. (Note: even low flow purging of these monitoring wells tends to cause considerable drawdown).

The State contends that the limestone bedrock formation is a potentially useable groundwater resource because it is part of the "Post-Maquoketa Aquifer." At best, this aquifer is potable only in limited areas in northern St. Louis County. Additionally, historic use of this aquifer has shown that useable resources, where available, are only present at depths of hundreds of feet below the ground surface.

SLAPS/HISS 3.4 Adequacy of Information

More information on the Post-Maquoketa Aquifer is needed to fully identify the risk of contamination in that system. No background data from this system has been collected and hydraulic parameters such as yield and hydraulic conductivity are unknown.

Wayne Interim Storage Site (WISS)

WISS 3.0 Site Characterization

The Wayne site consists of a 6.5-acre Wayne Interim Storage Site (WISS) and several vicinity properties. WISS is located at the former W.R. Grace and Company thorium processing facility in the Wayne Township, Passaic County, New Jersey. The vicinity properties, privately owned properties in the general vicinity of WISS, were also contaminated as a result of rare earth and thorium processing operations at the W.R. Grace facility.

The U.S. Congress through the Energy and Water Development Appropriations Act of 1984 assigned responsibility for the Wayne site to DOE as a decontamination research and development project. DOE placed the site in their FUSRAP. In October 1997, FUSRAP was transferred from DOE to the USACE by further Congressional action. The EPA listed the Wayne site on the NPL in 1984 as the W.R. Grace and Co., Inc./WISS. All USACE actions at the site are coordinated with EPA Region II undertaken pursuant to CERCLA, as amended by the Superfund Amendments and Reauthorization Act.

WISS 3.1 Geology and Hydrogeology

The uppermost bedrock beneath the site is the Lower Jurassic Boonton Formation consisting of alternating beds of reddish-brown sandstone, mudstone, and shale, aproximately 500 feet thick. Bedrock is typically encountered at 30 to 50 feet below the ground surface at the WISS (BNI, 1993). To the east of the site is a ridge formed of the Hook Mountain Basalt, which was formed contemporaneously with the deposition of the Boonton Formation.

A complex suite of glacially related materials overly the bedrock at the WISS. Two transmissive glacial units lie directly on the bedrock and, together, comprise the northernmost extension of the Buried Valley sole source aquifer. No contaminants related to the WISS have been detected in the Buried Valley aquifer.

USEPA Region II has designated a network of sole source aquifers beneath the WISS. The "Buried Valley" sole source aquifer lies beneath the WISS and is classified by USEPA as Class 2A;and is currently utilized for drinking water and other beneficial applications. The Buried Valley aquifer is artesian and confined and protected by a clay unit that appears to be laterally continuous across most of the WISS. It is possible that the clay unit may be breached in northwest corner of the WISS.

The wastes at WISS are emplaced within a bermed area within the fill and topsoil overlying the clay. It appears that in some cases, the wastes were emplaced directly into the upper surface of the confining clay layer.

WISS 3.2 Substances Detected at the Site Above Background Levels

WISS 3.2.1 Substances in Soil

The property is primarily contaminated with Th-232, Ra-226, and uranium, as a result of extraction of rare earth elements and thorium from monazite sand. Burial pits contain thorium processing wastes and building rubble.

"Twenty-seven metals were detected above background levels in surface and subsurface soil samples for the WISS property. Ten of the metals are associated with monazite sands, uranium ore/tailings, or other known feed materials processed at the former Rare Earths/W.R. Grace facility: arsenic, barium, beryllium, copper, cobalt, lead, molybdenum, nickel, selenium, vanadium. Chromium, mercury, and zinc occur naturally, but were found at levels above the background (BNI 1993). Fourteen rare earth elements were detected above background concentrations in surface and subsurface soils. The most frequent detections were cerium, lanthanum, neodymium, thulium, yttrium, and zirconium. SVOCs, VOCs, pesticides, and polychlorinated biphenyls (PCBs) were also detected in occasional surface and subsurface [soil] samples. The most frequently detected VOCs and SVOCs were toluene (73%) and bis(2-ethylhexyl)phthalate (30%), respectively. Two PCBs (Arochlor-1254 and Arochlor 1260) and four pesticides (4,4-DDT, aldrin, dieldrin, and endrin) were also detected in isolated samples [USACE 1999]."

Thallium has also been detected above background levels at the site. Many of the metal constituents, including arsenic (maximum concentration of 3770 mg/kg) and thallium (maximum concentrations of 55.1 mg/kg) are closely correlated with the location of the primary nuclides of concern. This indicates that they are associated with the ore processing wastes and suggests that remediation of the radionuclides would capture the metal constituents as well [USACE, 1999]."

WISS 3.2.2 Substances in Groundwater

Well locations for the WISS site can be found on Figure 2-12 in the back of this document.

Radionuclides

"Since 1984, samples collected as part of the groundwater monitoring have been analyzed for total uranium, Ra-226, Ra-228, and Th-232, and indicator parameters (total organic compounds, total organic halides, pH, specific conductance). During the fourth quarter of 1990 and the first, second, and third quarters of 1991, samples were collected as part of the RI and were analyzed for total and dissolved uranium, total and dissolved Target Analyte List metals, total and dissolved rare earth elements, and mobile ions, in addition to the regular suite of analytes described above. Selected samples collected during the third quarter of 1991 were also analyzed for Th-228, Th-230, lithium, VOCs, SVOCs, pesticides, and PCBs [USACE, 1999]."

One upgradient and three downgradient wells have been monitored periodically since 1994 for Ra-226, Ra-228, Th-232, Th-230, total uranium, a full suite of metals, and field parameters such as temperature, specific conductance, pH, Eh, DO, and turbidity.

The most commonly occurring radioactive elements in the shallow groundwater are Ra-226, followed by Th-228, Th-230, and Th-232. Federal and New Jersey MCLs are only established for Ra-226 and Ra-228 concentrations at 5 pCi/L combined. This value was periodically exceeded in three wells between 1991 and 1994 with a maximum value of 15.3 pCi/L for Ra-226 in 1992. It is interesting to note that the concentration of Ra-228 was approximately 10 pCi/L in both an upgradient and downgradient well in 1993. Since 1994, the groundwater sampling, limited to four wells, has been at or below the detection limit. Uranium has generally been below the proposed MCL since 1986, except in one instance where it was detected in 1993 in one well. However, uranium has consistently been measured above background (between 2 and 6 pCi/L) in two wells since 1986.

Metals

For the period of 1990 through 1997, the metals antimony, beryllium, cadmium, chromium, nickel, and thallium have exceeded their respective MCL value at least once. The rare earth elements erbium and lutetium were detected in unfiltered samples in bedrock wells in 1993. They were not detected in filtered samples indicating that they were present as particulates. Erbium had been previously detected once in another bedrock well in 1991.

Organics

"The analyses for organic compounds in groundwater samples indicate no persistent organic contamination in the site shallow groundwater. Trichloroethene was reported in well B37W08S in 1992 at an estimated concentration of 3µg/L, which is below the MCL of 5µg/L but above the New Jersey MCL for that contaminant (1µg/L). Pesticides and PCBs were not detected in groundwater samples.

Tetrachloroethene was detected in 1985 in samples from deep groundwater monitoring wells WISS-4B and WISS-5B at concentrations of 150 and 170µg/L, respectively. However, tetrachloroethene was not detected in any sample from these wells from 1986 through 1989 nor from 1991 through 1992 (DOE 1993). These wells were not sampled after 1992 [USACE 1999]."

WISS 3.3 Conceptual Ground Water Fate and Transport Model

There are two ground-water systems defined at the Wayne site. The shallow ground-water system at WISS is composed of waters within the overburden above a confining clay layer. These sediments are fluvial/alluvial materials with an average thickness of 17.5-ft. The lower ground-water system is within the non-lithified sediments below the confining clay unit and includes waters within the underlying bedrock. Static water conditions exist in the upper ground-water system, while the lower ground-water system exhibits artesian characteristics (USACE 1999).

The Boonton Formation and the Hook Mountain Basalt, which are the bedrock units underlying the site, are folded and fractured throughout the Newark Basin. The Boonton Formation is characterized by vertical jointing that is parallel and traverse to the strike of the beds (USACE 1999). Systematic fractures have been reported to occur in Newark Basin strata both as partings along bedding planes and as near vertical joint sets (Michalski 1990). Both permeability and storage of bedrock formations in the Newark Basin are fracture-controlled (Michalski et al. 1997). Therefore, bedrock ground-water flow models would probably be best explained by a complex leaky, multi-unit aquifer system where ground-water flow could be complex. In this model, a few bedding plane partings or fractures may dominate permeability distribution and groundwater flow. A near-vertical set of joints or fractures could provide leakage between discrete aquifer units. Lower permeability and greater storage could exist in the weathered bedrock than in the deeper bedrock (Michalski et al.1997).

The confining clay layer varies in thickness from 1.5 to 2.5-ft in the southeast and northeast corners of the site to a maximum of 15-ft in the northwest portion of the site. The clay layer has been interpreted as being continuous across the site except in the northern portion of the site where it may have been breached by waste emplacement. The extent of the clay unit outside the boundaries of WISS is not known. Where the clay unit is absent, there is likely communication between the two ground-water systems at the site. The potential for deeper ground water to be impacted is low of an upward vertical gradient present in the lower ground-water system as a result of artesian conditions (USACE 1999).

The primary source of contamination at WISS is contaminated subsurface soil, including material from the waste pits. Potential transport media at the Wayne site include surface water and sediment, air, and ground water. The ground-water monitoring network, which consists of wells located around the perimeter of the site, has not detected contamination levels that constitute a health risk. Ground water is not considered to be a mechanism for contaminant transport at this present time. However, future transport of contaminants via ground-water migration is the primary pathway of concern. Ground water in the immediate area of the waste pits has been impacted and will require remedial actions in conjunction with soil remediation activities. The potential exists for contaminants that are in locally impacted groundwater or being held by the soil matrix to migrate from the site over time (USACE 1999).

WISS 3.4 Adequacy of Information

The extent to which there is confinement by the clay layer at WISS is poorly understood. It is also possible that the characterizing this layer simply as a clay is inappropriate because it has been noted to contain significant quantities of gravel. Therefore, it is possible that a poor conceptual model has been perpetuated at WISS. Little is known about the quality or hydraulics of the ground water beneath the clay layer.

Maywood

Maywood 3.0 Site Characterization

The Maywood site is comprised of properties in the boroughs of Maywood and Lodiand the Township of Rochelle Park in Bergen County, New Jersey. These properties were contaminated by thorium processing at the Maywood Chemical Works (MCW) from the early 1900s to 1959.

The Maywood site is composed of the Maywood Interim Storage Site (MISS), and various nearby properties, including the Stefan Company property and numerous residential, commercial, and government properties. MISS, Stefan, and other nearby properties were once part of the former MCW property. The MISS is a 11.7-acre fenced lot that was previously part of a 30-acre property owned by the Stefan Company. MISS is a federally owned site, which has been used for interim storage of material from previously remediated properties. MISS is the only property that the federal government owns and controls directly.

Many of these properties have been remediated, or are scheduled for remediation under an ongoing CERCLA non-time critical removal action. The remaining properties contain soils with Th-232, Ra-226, and U-238, and their associated by-products. Chemicals are also known to be present on some of these properties.

The EPA placed the Maywood site on the NPL on September 8, 1983. DOE was given responsibility for the site in 1984 and transferred the site to FUSRAP. The USACE actions at the site are being coordinated with EPA Region II pursuant to CERCLA, as amended by the Superfund Amendments and Reauthorization Act.

Ground-water issues at the Maywood site will be addressed following completion of USACE's ground-water investigation and ground-water treatment studies being conducted by the Stefan Company. Ground-water contamination will be addressed in a separate FS/PP/ROD. The outcome of the ground-water investigation and the need for remedial action will be addressed in a separate CERCLA decision document. USACE'S responsibility with respect to any remediation of ground water will be consistent with the renegotiated FFA (SAIC 1998).

Maywood 3.1 Geology and Hydrogeology

The Maywood Site underlain by bedrock of the Brunswick Group which is currently used for drinking water or other beneficial use.

The uppermost bedrock beneath the site is Passaic formation (uppermost Triassic to lower Jurassic) of the Brunswick Group. The Passaic formation consists primarily of inter-layered dark to moderate reddish-brown, fine-grained sandstones and siltstones. High angle faults within the Triassic and Jurassic bedrock step down to the east and are tilted toward the south. Steeply dipping joints striking north to northeast parallel strike. A less prominent set of nearly vertical joints roughly parallels the dip of the bedding (DOE, 1992).

A complex suite of glacially related materials overly the bedrock at the Maywood Site. The ground surface was scoured and filled by glaciation during the Pleistocene. Drainage patterns were altered, and several morainal lakes were created. Wisconsin-age till, both stratified and unstratified, is common in the area.

Site borings show that the geology of the site can be divided into two major components. The bedrock of the Passaic formation is an interbedded, well-cemented sandstone and siltstone. Joints and fractures contain minor to complete secondary mineralization of calcite. Glacially related non-lithified clastic sediments overlie the bedrock.

The wastes were emplaced in the glacial overburden at Maywood. However, migration has occurred to the bedrock strata via groundwater.

Maywood 3.2 Substances Detected at the Site Above Background Levels

Maywood 3.2.1 Substances in Soil

The property is primarily contaminated with Th-232, Ra-226, and uranium, as a result of extraction of rare earth elements and thorium from monazite sand. Burial pits contain thorium processing wastes and building rubble.

Radioactive constituents are present in virtually all surface soils at MISS. Subsurface radiological contaminants are present over approximately 85 percent of MISS (SAIC 1998).

Seventy soil samples from the thirty-four boreholes were analyzed for metals. Twenty-three metals were detected; twenty-two were detected above background. Most of the metals occur within a parcel that extends from an area east of Building 76 (represented by boreholes C001, C003, and C022) to an area west of the storage pile (roughly represented by boreholes C025 and C029). Several boreholes that are peripheral to the storage pile (C031, C010, C006, and C029) and to the east of Building 76 (boreholes C001, C003, and C022) exhibited some of the highest concentrations of metals. These boreholes also contain some of the highest concentrations of radiological COCs in soils. Arsenic, chromium, copper, lead, lithium, and nickel were detected at least once at levels an order of magnitude above measured background. These metals also occurred at concentrations above measure background in a second, smaller area, represented by boreholes C026, C027, and C028, south of the storage pile. Lithium is associated with lithium wastes that are known to have been buried onsite. The extent of lithium in soils is widespread across the site (DOE 1992).

The coexistence of metals with radiological constituents was evaluated by the collection of chemical soil samples from areas of known radiological COCs, based on gamma log survey. Only lead and selenium were detected frequently in areas associated with radiological COCs.

The presence of some metals at MISS is possibly associated with the processing of monazite sands and disposal of lithium wastes at MCW. Most of the metal COCs were found in an area extending east of Building 76 and west of the storage pile. Only limited correlation between the detection of specific metals and specific areas and depth intervals of radioactive COCs were found.

There were thirty-four borehole locations for the MISS onsite chemical sampling program (also refer to the Maywood RI Report, Table 4-18). From these borings, a total of seventy-three soil samples were collected and analyzed for VOCs. Sampling depths ranged from near surface 0 to 2 ft to a maximum of 21.5 ft in borehole C004. Eleven VOCs were detected; four compounds were found at concentrations above mean reference baseline; benzene, 2-butanone, carbon disulfide, and toluene. Toluene was detected with the greatest frequency (10 out of 73 samples) (DOE 1992). PCE, the main VOC COC for groundwater, has not been detected in soils.

The coexistence of VOCs with areas and intervals of potential radioactive constituents was evaluated during this investigation by comparing the chemical data with gamma log results from the same borehole. In general, the low concentrations of VOCs onsite were detected with radioactive COCs and non-radioactive COCs (DOE 1992). The low frequency of detection and low concentrations found at MISS could be a result of sampling locations that were targeted more for defining radiological COCs, or that VOCs were not residually present in the soils.

Maywood 3.2.2 Substances in Groundwater

Radionuclides

Radionuclides at MISS have not been detected above regulatory guidelines (DOE 1992). In order to characterize radiological constituents in groundwater, selected samples from upgradient, onsite, and downgradient deep and shallow wells were analyzed for Ra-226, Th-232, and total uranium as standard analyses starting in 1986. In 1990 samples were analyzed for dissolved activity levels. Additional analyses were also conducted for Ra-228, Th-228, and Th-230. In most cases, radionuclide activity levels in ground water are approximately equal to or near background levels. Figure B-2 shows the locations of the MISS wells.

Background levels of total uranium ranged from 1.0 to 4.0 pCi/L. Downgradient wells showed a range of values from 0.9 to 8.9 pCi/L. Uranium concentrations in one well, B38W12A, ranged from 10.7 to 29 pCi/L. This well is located downgradient from the Sears and Stefan properties (DOE 1992).

Background levels of total Ra-226 ranged from 0.1 to 2.2 pCi/L. Downgradient wells showed comparable results. All wells except well MISS-4A had analytical results in this range. The maximum values for MISS-4A ranged from 2.3 to 8.0 pCi/L, sometimes above the regulatory guideline of 5 pCi/L for both Ra-226 and Ra-228 combined (DOE 1992).

Background levels of total Th-232 ranged from 0.1 to 1.8 pCi/L. Downgradient wells also fell in this range. The highest activity level detected was 3pCi/L in well MISS-4A during the fourth quarter of 1990 (DOE 1992). There is no regulatory guideline for Th-232.

The data indicates activity levels of radionuclides in ground water are not significantly above background levels in the vicinity of MISS. It is known that radionuclides are present in soils and surface sediments onsite and offsite, including soluble thorium compounds. Since these radionuclides and compounds are known to be present in the soil but not detected in significant amounts in ground water suggests they have been stabilized in sediments underlying MISS (DOE 1992).

Metals

Conclusions involving the metal contamination in groundwater have not changed since 1995 (DOE 1996). Data obtained during that time frame support most of the previous conclusions of the RI and the environmental surveillance program. The following is a summary:

- Metals that have occurred above MCLs are (1993 to 1995 sampling only):
  arsenic (SDWA MCL = 50 µg/L, NJGQS = 8 µg/L) - 2 to 93 µg/L (MISS-2A - 6,000µg/L),
  chromium (SDWA MCL = 100 µg/L) - 5 to 285 µg/L,
  iron (NJGQS = 300 µg/L) - 32 to 116,000 µg/L,
  lead (SDWA MCLG = 15 µg/L, NJGQS = 10 µg/L) - 2 to 37 µg/L, and
  manganese (NJGQS = 50 µg/L) - 9 to 63,100 µg/L.

- The background well (B38W02D) contains elevated concentrations of manganese, iron, and aluminum. These mineral reactive metals are common components of the sandstones that constitute the bedrock aquifer, occurring usually as oxide coatings on the surface of mineral grains. The occurrence of these metals in elevated concentrations in the bedrock wells and in the overburden wells can be attributed in most cases to fine grained minerals entrained in the sample. The iron/manganese/aluminum coatings of these minerals will tend to dissolve into solution when the sample is acidified.

- Use of low flow sampling has reduced the concentrations of iron and aluminum in the background well. However, concentrations of manganese remain high, suggesting that this metal is present in fine colloidal material or is dissolved. Bedrock wells have concentrations of manganese ranging from ~0.5 to 7.5 mg/L. The background well has a concentration range of 1.2 - 2.5 mg/L (NJGQS = 50 µg/L).

- Mineral reactive metals (aluminum, chromium, iron, and lead) occur as contaminants mainly in the overburden wells, in particular MISS-2A (arsenic - 6,000 µg/L and chromium 141 µg/L), MISS-1AA (chromium - 285 µg/L), MISS-7B (arsenic - 62 µg/L), and B38W17A (chromium -21,000 µg/L) (Fig. 4). With the exception of MISS-2A these wells are associated with the former retention ponds. Concentrations of chromium in samples taken in 1994 and 1995 range from 36 to 285 µg/L. Use of low flow sampling in 1994 and 1995 has resulted in lower concentrations of these metals: the concentrations of chromium are approximately half those from pre-1994 samples.

- Other metals that occur in elevated concentrations on MISS are lithium (50 - 14,000 µg/L) and boron (56 - 2080 µg/L). Lithium and boron are both elevated above background in bedrock and are attributed to contamination at MISS. These metals are mobile because they do not tend to react with minerals and have migrated away from the retention ponds into the bedrock. MCLs do not exist for lithium or boron in groundwater.

Use of low flow sampling has helped to reduce the apparent concentrations of some metals. However, the general distributions of metals are the same as in 1991 and the conclusions have not changed. Arsenic and chromium exceed MCLs in the overburden and are most likely attributed to metal contamination of groundwater by the retention ponds and contaminated soils. Manganese exceeds MCLs in most bedrock wells but is attributed to natural phenomena and not to MISS. Elevated concentrations of lithium and boron are attributable to MISS. Concentrations of arsenic and chromium in groundwater in the overburden close to the Retention Ponds will probably continue to sporadically exceed MCLs in the future (DOE 1996).

Organics

Conclusions for VOC contamination of groundwater at MISS have not changed significantly over the 1993 to 1995 time frame. Data obtained during that time supports most of the previous conclusions stated in the RI and the environmental surveillance program.

Tetrachloroethene (PCE) is the main VOC contaminant at MISS and, in the absence of organic matter in the subsurface, is generally mobile in groundwater. Contamination is primarily located in bedrock wells MISS-1B, -4B, -5B, -7B, B38W14D, B38W15D, and in downgradient shallow wells B38W14S, B38W15S, and MISS-7A. In general, concentrations of VOCs have increased since the introduction of low flow sampling. This would be expected, and the results are probably more representative of true groundwater concentrations, as this method causes less turbulence in the groundwater during sampling. With the exception of MISS-5B, the VOC contaminants are PCE and its breakdown products—TCE and vinyl chloride. MISS-5B is contaminated with Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) compound, however, the total BTEX concentrations between 1993 and 1995 are low (83 μg/L - 170 μg/L).

The VOC plume at MISS is located in the bedrock wells and further downgradient (Ballod property) in both bedrock and shallow wells. This could be a function either of more contamination in the shallow groundwater from the former ponds on Ballod or transport of VOCs in the bedrock upward into the shallow groundwater with ultimate discharge to surface water. Surface water from Westerly Brook had low concentrations of PCE breakdown products that the RI attributed to other sources.

The wells with the highest concentrations of PCE are located the furthest downgradient (B38W14S, B38W14D, and B38W15D). A plume of groundwater contaminated with PCE and its daughter products exist in bedrock below MISS and Ballod. The extent of the PCE plume downgradient from MISS and Ballod has not been defined and needs to be characterized. This plume is probably contiguous beneath the former retention ponds. Based on the hydrogeological conceptual model in the RI, the fate of PCE contaminated groundwater is likely to be downgradient transport and discharge of bedrock groundwater to surface water bodies so the likely ultimate fate of PCE in bedrock groundwater is to be discharged into Westerly Brook or the Saddle .

Additional data are needed to proceed with evaluating remedial strategies for VOCs in groundwater. These data are needed to define the extent of the groundwater plume (DOE 1996).

MISS 3.3 Conceptual Ground Water Fate and Transport Model

The site conceptual model for groundwater flow and contaminant migration for the Maywood Site that was presented in the Maywood Remedial Investigation (RI) (DOE 1992) and Maywood Groundwater Sampling and Analysis Plan (SAP) has been revised after further study. Regional geologic and hydrogeologic data as well as information gathered from the Maywood Site and Stepan Company properties RI reports have been integrated into this revised interpretation of site conditions (USACE 1997).

As stated in the Maywood Site RI (DOE 1992), groundwater flow in the Passaic Formation or bedrock aquifer at MISS is controlled by secondary porosity associated with fractures and joints in the formation. Systematic fractures, both near-vertical and partings along bedding are generally believed to provide the principal passages for groundwater flow in the Passaic Formation (Michalski 1990). Near-vertical fractures along strike may be a significant factor for transmitting groundwater in the Passaic Formation. Observations throughout the outcrop area in New Jersey indicate there is usually one set of vertical joints that roughly parallel the strike of the beds, and a second set that is generally perpendicular (Vecchioli et al 1969).

A recently published scientific article has provided a more complicated interpretation of groundwater flow in the Passaic Formation in the Newark Basin of New Jersey. A leaky, multiunit aquifer-system (LMAS) has been proposed to interpret groundwater flow in the Passaic Formation consisting of thin water-bearing units and much thicker intervening aquitards. In this model, a few bedding plane partings or fractures may dominate permeability distribution and groundwater flow. A near-vertical set of joints or fractures could provide leakage between discrete aquifer units. While the dominant flow within the near-vertical joints or fractures is along strike, there could be flow patterns developed in fracture sets perpendicular to strike, particularly with depth (Vecchioli et al 1969). Lower permeability and storage is more likely to exist in the weathered bedrock than in the deeper fresh bedrock (Michalski & Britton 1997).

The configuration of planar and linear features of the bedrock strata and the LMAS concept are critical to understanding the groundwater flow and contaminant migration at the Maywood Site and the relationship to possible source areas. Most of the elevated concentrations of VOCs, and to a certain degree, metals in groundwater at MISS and Ballod have been in the bedrock aquifer. A recently published geologic map (Parker 1993) indicates the bedrock at the Maywood Site has a northeast-southwest strike with a dip of 7 to 12 degrees to the northwest. The study area lies in the Saddle River Basin. MISS itself lies at the western edge of the upland divide between the Saddle River and Hackensack River Basins. The basin divide as well as the eastern and western edges of the upland divide correspond to ridge axes that are resistant sandstone outcrops of the Passaic Formation. According to the topographic map, MISS, the groundwater investigation area, and the industrial /residential area located north of the site are situated in a depression or trough between higher topographic expressions of the ridge. This feature, along with the strike and dip of the strata, is probably significant in terms of groundwater flow and migration of VOCs.

The approximate location of the ridge axis makes up the western upland divide and its relationship to the groundwater monitoring wells at MISS and Ballod. Recent information has indicated the presence of a solvent manufacturing plant north of MISS, which is a potential source of the PCE and its degradation products found in wells on the western edge of MISS. The location of the groundwater monitoring wells that consistently show elevated concentrations of VOCs are west of the upland divide boundary, as is the solvent manufacturing facility.

Other potential sources of VOCs (including BTEX) and metals measured in wells on MISS have been identified on the Stepan property. It is probable that elevated VOCs and BTEX found in several wells east of the western edge of upland divide could be related to corresponding groundwater plumes delineated upgradient at the Stepan property.

Concentrations of PCE and its degradation products, TCE, 1,2 DCE, and vinyl chloride were measured in wells located on MISS and Ballod properties from 1985 to 1996. Elevated VOC concentrations in well nests B38W1 and B38W7 have only been found in the wells open to the bedrock aquifer. The well pairs located on the Ballod property (B38W14 and B38W15) have shown elevated VOC concentrations in both the overburden and bedrock aquifers. A possible explanation is that VOCs have migrated upward from the bedrock aquifer in the area of the Ballod wells. The potentiometric head measured in the bedrock aquifer in well nest B38W14 on the Ballod property is approximately twice that recorded in the overburden aquifer, indicating an upward gradient in that area (DOE 1992). Elevated VOC concentrations have also been recorded at the surface water sampling location SW2 where Westerly Brook emerges from a culvert downstream of MISS (DOE 1992). Based on this information, it can be surmised that a discharge area into Westerly Brook occurs somewhere in the vicinity of well nest B38W14. Both the B38W14 and B38W15 well nests are in an area where there is no weathered bedrock present, therefore providing a more conductive interface for groundwater flow and contaminant migration.

MISS 3.4 Adequacy of Information

There is adequate information to determine analyte presence in ground water at the MISS. However, additional ground-water investigation is needed to determine the extent of VOC and metal contamination downgradient of MISS. The extent of the PCE plume downgradient from MISS and Ballod needs to be defined. For example, PCE is detected in ground water but has not been detected in soil at MISS, based on this, further investigation into whether or not PCE is actually a site contaminant is necessary. The LMAS model also brings about questions concerning ground-water flow and possible contaminant distribution both downgradient and along strike in the deep bedrock in the vicinity of MISS.

Middlesex Sampling Plant (MSP)

MSP 3.0 Site Characterization

The former Middlesex Sampling Plant (MSP) is a 9.6-acre site located in the Borough of Middlesex, Middlesex County, New Jersey. The MSP facility was established in 1943 as part of the MED to sample, store, test, and transfer ores containing uranium, thorium, and beryllium. In 1946 the MED was deactivated and MSP activities continued under the AEC. AEC terminated the primary operations (i.e. uranium assay analysis) at the site in 1955. After 1955, the site was used only for storage and limited sampling of thorium residues. All AEC activities at the site ended in 1967. However, the site remained under government control. MSP was placed in DOE custody when radioactivity above current guidelines was discovered. DOE subsequently placed the site in their FUSRAP. In October 1997, FUSRAP was transferred from DOE to the USACE by further Congressional action.

The EPA recently placed the former Middlesex Sampling Plant (MSP) on the NPL on February 19, 1999. The USACE actions at the site are being coordinated with EPA Region II pursuant to CERCLA, as amended by the Superfund Amendments and Reauthorization Act.

MSP 3.1 Geology and Hydrogeology

MSP is located in the northwest portion of Middlesex County, New Jersey. The MSP study area is part of the Piedmont geomorphic province in New Jersey, which is part of the Newark Basin, a regional geologic trough that is a half-graben bounded on the northwest by a fault (Olsen 1980). Most of this province is a maturely dissected peneplain, sloping gently to the coast. The regional topography displayed is hilly to rolling terrain with a few high ridges. In central New Jersey, the Newark Basin forms a broad, structural basin that trends southwest to northwest forming a lowland plain.

MSP is located within the Newark Basin underlain by the late Triassic/early Jurassic age Passaic Formation of the Brunswick Group, Newark Supergroup. In this area, beds of the Passaic Formation have a northeast-southwest strike and a dip of 10 degrees to the northwest based on measurements taken from an outcrop adjacent to MSP. The bedrock at MSP has been reported as moderately to highly fractured with fracture frequency decreasing with depth (Weston 1980, BNI 1993b), this is consistent with the literature describing the Passaic Formation

The geologic units at MSP were described from available geologic logs from BNI and the Phase I monitoring wells installed by Roy F. Weston, Inc., in 1980. Lithologies are described in the following descending order: asphalt and crushed stone; fill (which can include pipe chase backfill associated with underground storm drainage pipes); gravely sand (native material rarely found onsite); sandy silt (native material rarely found onsite); a silty clay unit found in the southern portion of the site; weathered bedrock identified as a silty clay or sandy silt with decomposed shale or siltsone fragments; weathered bedrock consisting of shale or siltstone that displays bedding features, with associated voids, and fractures; and unweathered bedrock which is comprised of shale or siltstone that shows bedding features, with associated voids and fractures (SAIC 1997). A stratigraphic column is located at MSP Figure 3.1.

The Passaic Formation is a major aquifer throughout a large part of central and northeastern New Jersey. The aquifer is used for domestic, municipal, and industrial water supply in Middlesex County and surrounding counties with pumping rates ranging from a few to several hundred gallons per minute (Michalski 1990). Groundwater flow is controlled by secondary porosity associated with fractures and joints in the formation.

Systematic fractures, both near-vertical joints and partings along bedding, are generally believed to provide the principal passages for groundwater flow in the Passaic Formation.

The shallow groundwater flow patterns and possible contaminant migration at MSP are relatively straight forward and have been defined (BNI 1997b). The potentiometric surface generally fluctuates within the two weathered bedrock units and comes in contact with contaminated fill, pipe chase materials, or past contamination including sediments associated with the process building sump. The shallow potentiometric surface (BNI 1997a) shows a groundwater divide in the northern portion of MSP indicating flow toward the north and south from the sump containing contamination. The configuration of the storm drains, fill, top of weathered bedrock, and well screened intervals would allow contaminants in the sump storm drain(s) to gain entrance into the groundwater system (SAIC 1997).

The deeper groundwater system at MSP is not well defined at this time. Wells that extend to depths of 35 feet below ground surface or greater were installed in 1980 or 1981. These wells were not constructed to current well standards and could not provide adequate data for analysis. All of the deep wells in this category have been closed or not sampled since the 1980s.

MSP 3.2 Substances Detected the Site above Background Levels

MSP 3.2.1 Substances in Soil

In-situ soil contamination has been previously characterized in other reports following investigation during 1983 and 1991. The 1983 investigation was focused on radiological characterization whereas the 1991 investigation emphasized chemical contaminants. As expected based on past operations, the primary contaminants at the Middlesex site in surface and subsurface soils are radionuclides (U-238 and Ra-226, with lesser amounts of Th-232).

Based on historical investigations, a review of the screening of the combined soil data set against background values is presented with the identification of site-related contaminants (SRCs). As no new data was collected for the MSP RI, the historical data is used in determination of SRCs. The soil data is discussed as surface soils, those ranging from 0 to 2 feet below the surface with subsurface being defined as greater than 2 ft. As previous soil sampling required drilling through the asphalt, the upper limit of the surface soil horizon was set to the base of the asphalt horizon (i.e., the asphalt/soil interface depth was set to 0 feet) (USACE 1999.

Inorganic contaminants detected above their associated background in the surface soil from 1 to greater than 2 feet are arsenic, barium, beryllium, boron, cadmium, chromium, cobalt copper, lead, manganese, silver, nickel, and zinc. Barium and manganese were both found at concentrations far above their associated background, as high as 520 mg/kg with a background of 88.6 mg/kg and 1670mg/kg with a background of 725 mg/kg respectively. Selenium and vanadium were found at concentrations greater than their background from the surface to 2 feet in depth. Antimony and mercury were found in concentrations above background only greater than 2 feet below the surface. Erbium, Cerium, and Thulium were rare earth metals detected above background.

Radionuclides found with concentrations above their backgrounds from the surface to a depth of greater than 2 feet included Ra-226, Th-232, total uranium, and U-238 with concentrations reducing with depth. Their background criteria are 0.99pCi/g, 1.14pCi/g, 4.27pCi/g, and 2.09pCi/g respectively. Radium-226 had a maximum concentration of 735.7 pCi/g in soil <2 feet and a maximum of 54.6 pCi/g in soil > 2 feet below the surface. Uranium-238 maximum concentration were 961.4 pCi/g and 37.9pCi/g in soil < 2 feet and > 2 feet below the surface. The maximum total uranium concentration did not change very much changing from depths of 0-2 feet and > 2 feet, they were 18.56pCi/g and 13.57pCi/g respectively. U-238, however showed a maximum concentration of 961.4pCi/g in soil <2 feet and 37.9pCi/g in soil >2 feet.

MSP 3.2.2 Substances in Groundwater

Impacted groundwater is present within the weathered fractured bedrock and radionuclides are most likely either dissolved or colloidal. Filtered and unfiltered sample results have similar values about 50% of the time implying there is a significant particulate fraction as well as a dissolved or colloidal phase. Most of the monitoring wells that have shown elevated activity levels during 1994 to 1998 ground-water sampling were screened in the weathered fractured bedrock.

Chemical concentrations in groundwater have been evaluated based on several standards, the most stringent of which are generally the SDWA MCLs established by EPA for drinking water systems. In addition, the New Jersey Groundwater Quality Standards (NJGWQS) for Class II-A waters established by the State of New Jersey have been used for comparison purposes.

Radionuclides

Radioactive constituents have been detected above SDWA MCLs (or proposed MCLs) in groundwater at the Middlesex site as follows:

1994 – (Ra-226 + Ra-228): B18W24S, B18W26S, and B18W28S
1994 – U-238: B18W25S, B18W28S
1995 – (Ra-226 + Ra-228): B18W29S
1995 – U-238: B18W24S, B18W30S
1996 – U-238: B18W24S, B18W30S, B18W31D, B18W31S, B18P01
1997 – U-238: B18W24S, B18W25S, and B18W30S.

B18W24S has shown increasing concentrations of U-238 over the last four years with a record increase in 1997. B18W30S has consistently shown elevated U-238 concentrations (USACE 1999). MSP well locations can be found on Figure 2-1 in the back of this document.

Metals

Chemical concentrations in groundwater have been evaluated based on several standards, the strictest of which, generally the SDWA MCLs, established by EPA for drinking water systems. In addition, the New Jersey Groundwater Quality Standards (NJGWQS) for CLASS II-A waters established by the State of New Jersey have been used for comparison purposes.

Common, naturally occurring metals, such as aluminum, iron and manganese are reported in several wells at concentrations above state groundwater quality criteria. Exceedances in concentrations of metal contaminants (arsenic, beryllium, chromium, lead, and nickel) are observed in several onsite wells but concentrations are considerably lower in the downgradient offsite well. The elevated concentrations do not indicate a clear pattern of heavy metals impact in the local area. No significant source of metals contamination is present at the site; however, lead and beryllium have been detected in several surface soil samples along the western portion of the site at or above the New Jersey proposed surface soil remediation guidelines. None of the subsurface soil samples exceeded the proposed subsurface (impact to groundwater) soil remediation guidelines. Both lead and beryllium are probable constituents of the uranium, thorium, and beryllium ores that were handled at the Middlesex site (BNI 1993b). The collection of filtered and unfiltered samples in 1994 and 1995 indicated that no offsite migration of dissolved metals is currently occurring (BNI 1997c).

Organics

Since 1994, organic compounds have been detected in all the existing wells except B18W30S, and of the compounds detected, bis(2-ethylhexyl)phthalate (for monitoring events in 1994, 1996, 1997), 1,2,4 trichlorobenzene (for monitoring events in 1994) and dichloromethane (methylene chloride) (for monitoring events in 1997) exceeded SDWA limits. Concentrations in soil of these same compounds that exceed drinking water limits are all well below the New Jersey proposed soil remediation guidelines for residential direct contact (surface soil) and impact to groundwater (subsurface soils) concentrations. Therefore, these detected compounds are not necessarily associated with onsite soils (BNI 1995).

Methyl-tert-butyl ether (MTBE), a common gasoline additive, was detected in wells B18W26S, B18W27S, and B18W28S in 1996. The highest concentrations (700 to 800 μg/l) were detected in well B18W27S, which is at the southwestern corner of the site. MTBE was detected in 1994 in this well at a concentration of 300 μg/l. Although there is no regulatory limit specified for this compound, MTBE is more soluble than other constituents of gasoline (e.g., benzene, toluene, and xylene) and would probably be detected at the leading edge of a gasoline plume. Thus, MTBE may be an indicator of petroleum migration onto the site from an adjacent property; the west side of MSP borders an industrial vehicle salvage facility (BNI 1997c). No MTBE was detected in the northern well close to the MSP garage. The MSP garage has concrete floors and was used for parking cars during the MED period (1943–1968) and for trucks during the U.S. Marine Corps period (1969–1979). It is currently used for parking trucks and as a workshop.

MSP 3.3 Conceptual Groundwater Fate and Transport model

The conceptual ground-water flow model of the Passaic Formation in the Newark Basin has evolved over recent years. When the ground-water monitoring network was installed at MSP, a two aquifer equivalent porous medium was interpreted at the site. Recently published scientific articles (Michalski 1997 and Morin et al 1997) have provided a different interpretation of groundwater flow in the Passaic Formation or bedrock in the MSP area. One article proposed a LMAS to interpret groundwater flow at a site approximately 4 miles along strike from MSP in the Passaic Formation. In this model, a few bedding plane partings or fractures may dominate permeability distribution and groundwater flow. A near-vertical set of joints or fractures could provide leakage between discrete aquifer units. Lower permeability and greater storage could exist in the weathered bedrock than in the deeper bedrock (Michalski 1997).

Reviewing site conditions as related to the LMAS conceptual model , the weathered bedrock units would be classified as the "transition zone" and the unweathered bedrock as a "discrcte aquifer." An increase in transmissivity and steeper hydraulic gradient was noted in the 15 to 25 ft depth interval during the 1980 groundwater study which could correlate to the approximate depth of the unweathered bedrock. At this depth, the hydraulic conductivity and groundwater flow velocity could be greater than the weathered bedrock, partly because of lesser amounts of clay filling fractures. Once groundwater enters the unweathered bedrock, flow patterns at some depth would also be different than the overlying shallow bedrock, following fractures and bedding planes primarily along strike (SAIC 1997).

The principal release mechanism is infiltration and leaching to groundwater. Water is introduced to contaminants buried in the soils by infiltration of rainwater. Contaminants are then leached from contaminated soils and migrate vertically downward through the vadose zone to the water surface. In addition, there is evidence that historically groundwater seeped into the underground storm sewer conduit that emptied into the drainage ditch. These pipelines were abandoned during the late 1990s, but the gravel backfill around the drainage lines almost certainly serves as localized preferential flowpaths. The horizontal hydraulic conductivity (which controls flow rate) is a function of soil grain size and the pressure gradient. Saturated hydraulic conductivities for MSP range from 3×10^{-5} to 5×10^{-4} cm/sec. The saturated groundwater system at MSP is composed of an upper zone in the overburden and the top of the bedrock and a lower bedrock zone. The overburden of 2- to 8-ft thick silty to sandy loam soils form the vadose zone above the shallow aquifer system. Groundwater at the MSP site flows in a southernly direction. The potentiometric surface map for monitoring wells installed in 1980, 1981 show groundwater flow toward the southwest from the site (DOE, 1995). In accordance with the LMAS model previously discussed, a more significant pathway for off-site migration may exist in the unweathered bedrock as associated with the higher hydraulic conductivity of the fractures and bedding plane partings (DOE, 1995).

Surface water, which may include groundwater discharge in the area south of the site, discharges into the drainage ditch and intermittent stream and eventually into a larger ditch. Sediment transported from MSP by surface water would contribute an insignificant amount of contamination due to the asphalt covering most of the site.

MSP 3.4 Adequacy of Information

There is adequate data to characterize the shallow ground-water system collected from 1994 to 1998. However, there would have to be additional characterization of the deeper ground-water system in order to provide adequate aquifer characteristics and analytical data.

Tonawanda Area Sites

Tonawanda 3.0 Site Characterization

The Tonawanda properties include Linde, Ashland 1, Ashland 2, and Seaway.

Linde

The Linde site is approximately 135-acres in area and is bordered on the north and east by wetlands. The MED was contracted by Linde Air Products Corporation to separate uranium from uranium ore from the time of 1942 to 1948. Five of the many buildings on site were involved in MED activities. Under MED contract, three domestic and four African ores were processed. Liquid and solid wastes were generated; liquid wastes were disposed through injection wells while solid wastes were then dumped at the Ashland 1 site and later Ashland 2 and Seaway.

Currently the site is fenced with security guarding the plant 24 hours a day. The site is an operating industrial plant owned by Union Carbide Industrial Gases. Buildings on the site are currently used for offices, research laboratories, fabrication facilities, and warehouse storage areas (DOE 1992).

Ashland 1 and 2

Ashland 1 is a 10-acre area used to store low-grade uranium ore tailings that were produced on the Linde site. Contamination ranged from depths of 0 to 5 feet. Approximately 8,000 tons of residues were dumped on Ashland 1 from 1944 to 1946. In 1958 the Environmental Measurements Laboratory conducted a radiological study and AEC released Ashland 1 for use without removal of the contamination. In 1960, Ashland Oil acquired the property and used it for oil refinery activities. In 1974 Ashland Oil constructed two petroleum product storage tanks and a drainage ditch, the excavated soil was transported to Seaway and Ashland 2 for storage and disposal (DOE 1993).

"A portion of the Ashland 2 property was used by Ashland Oil as a landfill for disposal of general plant refuse and industrial and chemical byproducts. The radioactive residues removed from Ashland 1 were deposited in an area of Ashland 2 adjoining the Ashland Oil landfill area. At present, the Ashland 2 property is vacant and is covered by grass, bushes, and weeds; no commercial operations are now being conducted (DOE 1993)."

Seaway Industrial Park

Seaway Industrial Park is approximately 100 acres and has been used as a landfill for approximately 50 to 60 years. In 1946, radioactive residues from Ashland 1, which are discussed above, were deposited in three areas on the Seaway site. In 1974 approximately 6,000 yd^3 of low-grade uranium ore contaminated soil were excavated from Ashland 1 and placed in three areas of the landfill, a total of approximately 49,400 yd^3 radioactively contaminated material lye on the site. Since then, some of the contaminants have been buried under other refuse and fill material.

Tonawanda 3.1 Geology and Hydrogeology

The Tonawanda sites are located in the Niagara Frontier area of the Central Lowlands Physiographic Province. The regional geology consists of a series of marine sedimentary rocks bounded by non-lithified glacial and alluvial sediments above and crystalline basement below. A stratigraphic column of the sites are located on Tonawanda Figure 3.1, a general site geology is listed below:

Unit 1: Topsoil-brown silty clay or clayey silt
    0-1 ft
Unit 2: Glacial overburden, clay, 0-20 ft of the overburden is saturated
    68-90 ft
Unit 3: Basal glacial and silty sand and clayey gravel

Subunit 1:	silty sand
Subunit 2:	poorly sorted gravel, shale, gypsum, and some quartz
Subunit 3:	well sorted saturated sand
Subunit 4:	clayey gravel

Unit 4: Camillus Shale-gray calcareous mudstone
    Up to 50% thin gypsum layers

"Groundwater in the Tonawanda area is considered to be in three general zones. The first zone is the unconsolidated glacial till and glaciolacustrine clay. The second is a series of soluble limestones and dolostones that surround the third, the Camillus Shale. The Camillus Shale is considered to be the most important unit and is defined as a single aquifer because of its extremely high conductivity (BNI 1991a)." Water from the Camillus Shale is of poor quality and considered unfit for human use.

Tonawanda 3.2 Substances Detected at the Site Above Background Levels

Tonawanda 3.2.1 Substances in Soil

Linde 3.2.1.1

U-238, Ra-226, and Th-230 are the primary radioactive isotopes in the surface and subsurface soils across the site. The greatest depth of contamination is 8 feet deep, this occurs under four buildings located in the eastern portion of the site. The other radioactive contamination is on the surface level up to 4 feet in depth.

MED-related metal precipitates were found in excess of background levels but are not considered RCRA hazardous waste. "The RI investigation determined that the metals related to the MED processing have remained with the MED-related radionuclides, rather than migrating from the MED waste materials. In addition, the RI concluded that the commingled contaminants have remained immobilized in the near-surface soils (BNI 1993)."

Ashland 1 3.2.1.2

Uranium, radium, thorium and their radioactive decay products are the primary radioactive contamination of concern in the surface and subsurface soils at Ashland 1 and 2. Th-230 is the dominant isotope.

Elevated levels of these three radionuclides are found from the surface level to a depth of 5 feet on the Ashland 1 property. There is an estimated 120,200 yd^3 of contaminated soil on the site (DOE 1993). U-238 ranged in depth and was found at concentrations of 0.6 to 750 pCi/g. Ra-226 was found the least of the three radionuclides in concentrations of 0.6 to 750 pCi/g. Th-230 was found from depths of 0 to 2 feet with concentrations of 0.9 to 1500 pCi/g.

Chemical characterization of Ashland 1 found only one soil sample to fail the EP toxicity test for chromium and is therefore by RCRA standards there is a potential for hazardous waste to be present. Concentrations of lead and vanadium also were found substantially above background levels at both Ashland 1 and 2.

There is approximately 52,100 yd^3 of radioactively contaminated soil at the Ashland 2 site ranging in depth from 0 to 9 feet. Ra-226 and U-238 were usually found in the same areas and at depths ranging from 0-3 feet with concentrations reaching 189 pCi/g and 263 pCi/g respectively. Th-230 was detected throughout the contaminated areas and along drainage creeks with concentrations ranging to 2200 pCi/g.

Seaway 1.3.2.1.3

The primary radioactive contaminant at Seaway is Th-230, however, characterization results indicate that soils from Seaway are not considered RCRA hazardous. The total volume of contaminated soil at Seaway is approximately 117,000 yd^3 (DOE 1993).

Tonawanda 3.2.2 Substances in Groundwater

Radionuclides

Groundwater monitoring indicates that radioactive contaminants are not leaching into the deep or shallow aquifer on the Linde, Ashland, and Seaway sites. The shallow system flows horizontally and has a high contaminant retardation and low percolation rate through the clay layer above. Slightly elevated concentrations of radionuclides were found in the shallow aquifer on the Ashland sites but the concentrations are well below DOEs DCGs and drinking water standards guidelines and the aquifer is not used for drinking water. Monitoring at the Ashland sites also indicate no radioactive contamination in the deep groundwater zone.

Inorganics

Elevated concentrations of sodium, sulfate, and chloride were found in the deep aquifer system at Linde. However, these inorganics are considered immobile due to the low permeability of the shale and low flow velocities.

Tonawanda 3.3 Conceptual Ground Water Fate and Transport Model

Linde

DOE lists the primary mechanisms for releasing potential contaminants into the environment as leaching of subsurface contaminants into the groundwater, storm water runoff and infiltration, resuspension of contaminated particulate matter, and Rn-222 emission.

The surface soils on the Linde site consist of a clayey matrix. Large areas of the site are covered with asphalt and buildings. This reduces the amount of infiltration into the subsurface. However, infiltration occurs throughout the site in areas of gravel and vegetation. Water percolation through the clay layer may result in partial or full adsorption of the contaminated material before reaching the shallow groundwater system. Computed flow velocities and the low permeability shale in the deep aquifer indicate that it is fairly immobile.

Ashland 1, Ashland 2, Seaway

Stormwater runoff and infiltration are the primary mechanisms of release for the Ashland 1, 2, and Seaway sites. These sites also exhibit a clayey matrix of surface soils reducing water infiltration and increasing runoff.

"Groundwater monitoring results indicate that radioactive contaminants from the contaminated areas on the Ashland properties are not migrating to the deep or shallow confined groundwater systems. The thick clay layer above the groundwater acts as an aquitard to mitigate downward migration of contaminants. Slightly elevated concentrations of radioactive contaminants, well below DOE DCGs and drinking water standards, were recorded in one well located in the perched groundwater system. The highest concentrations detected in this well in over three sampling events in 1989 were Ra-226, 1.4 pCi/l and Th-230, 0.2 pCi/l. This groundwater system is not used as a drinking water supply (DOE 1993).

Tonawanda 3.4 Adequacy of Information

Information collected on this site is adequate at this time.

Luckey

Luckey 3.0 Site Characterization

In 1942, the Defense Plant Corporation (DPC) built a magnesium reduction plant at the site in Luckey, Ohio, .22 miles southeast of Toledo. The facility was operated during World War II by a DPC contractor, the Magnesium Reduction Company, as assignee for the National Lead Company. A multiple-retort ferro-silicon or Pigeon process produced metallic magnesium from dolomitic limestone (PRC 1995). The Pigeon process exposed dolomite (containing magnesium) and ferro-silicon to heat, producing a magnesium fume which was cooled by non-contact water to form solid magnesium. A residue, consisting of iron, silicon, and calcium, was also created (Cline 1990). The residue was deposited in a quarry that was operated by Kelly Island Stone and Limestone (Kelly Island and DPC 1943) and later purchased by Basic, Inc. (Basic Inc., 1958). This Kelly Island quarry is now known as the Luckey Dump or Troy Township dump. It is reported that an abandoned oil/gas well is present on the Luckey Dump site. The magnesium reduction plant was closed in November of 1945 as a war surplus plant, and based on employee interviews (Singleton 1990), production was never reinitiated.

Custody of the plant was transferred to the Reconstruction Finance Corporation who leased the entire site to Brush Beryllium Corporation (BBC) in 1949. BBC entered into a contract with AEC to design, construct, operate and maintain a plant for the production of beryllium and to maintain the former magnesium plant facilities in stand-by status (SAIC 1996). The new beryllium capacity was needed because fire destroyed the privately owned beryllium production plant in Lorain, Ohio. BBC operated the AEC-owned beryllium production plant between 1949 and 1958. BBC records (Powers 1983) indicate that the plant produced primarily beryllium hydroxide throughout the life of the plant. In the years 1950 through 1953, the plant also produced beryllium metal in vacuum cast billets from beryllium hydroxide and some beryllium oxide from the beryllium hydroxide. Most of the beryllium hydroxide was sold to BBC's Elmore, an Ohio plant that used the beryllium hydroxide to make beryllium copper alloys. According to interviews, air handling and safety procedures were established throughout the entire plant including the overhead beams and ceiling which were washed and scrubbed monthly (OEPA 1997). BBC transferred beryllium production operations to a new facility in Elmore, Ohio in 1958.

In late 1951, AEC shipped about 1,000 tons of scrap steel containing various radionuclides to the site from the LOSA. Records indicate that plans were made to restart magnesium production and the scrap was intended to scavenge chlorine from the process. However, according to a former employee (Cline 1990), the scrap was to be used in the setup of the beryllium process. Most of the scrap was found unusable may have been sold to local scrap dealers.

Luckey 3.1 Geology and Hydrology

The Luckey Site is located in the Lake Plains Physiographic province and sits on a mantle of non-lithified glacial deposits overlying a sequence of relatively flat-lying sedimentary rocks. The bedrock consists of mostly dolomitic Silurian and Devonian age rocks.

Across Gilbert Road to the south of the site is the France Stone Quarry, which penetrates into dolomite. The depth to bedrock there is only a few tens of feet. Along Gilbert Road to the west, bedrock depth is only 22 to 29 feet and there is a bedrock outcrop east of the site. At the site bedrock depth was around 20 feet. According to Glaze (1972) the site is underlain by the Middle Silurian Lockport Group. This undifferentiated group is described as a massive blue-gray to white porous dolomite with an average thickness of 200 feet (Smith and Sabol, 1994).

Luckey 3.2 Substances detected at the site above background

Luckey 3.2.1 Substances in Soil

Background values have not been chosen for the Luckey site. The comparisons below are made to a background value that consists of the UCL95 for a normally distributed population. These comparisons are not complete but preliminary. More complete comparisons will be made during the preparation of the RI.

Using the UCL 95 for a normal distribution as a background statistic 17% of the soil samples exceed the background for U-238. Background is exceeded for Ra-226 in 41% of the samples and for Th-230 in 46% of the samples. These three radionuclides and their daughters are the primary radionuclide COCs.

The metal COCs are arsenic, barium, beryllium and lead. All of these are thought to have been present in the beryllium ore that was processed at the site. A majority of the surface of the site exceeds background concentrations for beryllium. Thirty eight percent of the samples exceed background concentrations for lead with the highest concentration over 6000 ppm. Twenty nine percent of the samples analyzed for barium exceeded the background concentration. Forty percent of the samples analyzed for arsenic exceeded the background concentration. Cadmium, which is not a COC, is present in elevated concentrations and caused one sample to fail the TCLP test. Fifty three percent of the samples analyzed for cadmium exceed the background concentration with the highest concentration in the sample that failed, being 438 ppm.

It should be noted that all of the background samples as well as all the onsite samples exceed the Region 9 residential PRG for arsenic (cancer endpoint).

Evaluations of organics in the Luckey soils have been restricted to comparisons to RCRA lists of hazardous wastes. A number of f-listed wastes are present in the Luckey soils although the concentrations are low. PAH's are present in a few samples at levels that exceed Region 9 PRGs and PCB's are present in several samples at concentrations of up to 3 ppb.

Luckey 3.2.2 Substances in Groundwater

Evaluations of the relationship between the onsite/offsite monitoring wells and the background are incomplete. It is expected that these relationships will be evaluated during the compilation of the RI. The following information is preliminary and subject to change.

Radionuclides

A number of radionuclides have been detected in groundwater onsite. Gross alpha (27 pCi/l), exceed its MCL and uranium concentrations were found to exceed 88 pCi/l. One sample is reported to have a high level of thorium-234 (201 pCi/l) although the result is labeled as an estimated quantity.

Radium-226 and thorium-230 concentrations exceed background in 25 % and 10 % of onsite samples respectively. Uranium-238 concentrations exceeded background in roughly 70% of the onsite samples.

Offsite samples taken from the wells to the north of the site also show some elevated concentrations of radionuclides above the average of background. However most are within the range of values seen in background samples.

Metals

Aluminum, iron and manganese exceed secondary drinking water standards in groundwater samples from onsite. Beryllium, lead, nickel and thallium exceed primary drinking water standards. The first sample taken from immediately north of the site did contain beryllium above the MCL however it was judged not to be a significant short-term hazard. Subsequent sampling has resulted in non detects for beryllium. Sampling from Uretech's west production well (inactive) resulted in analyses exceeding the MCL. Only the east well is currently in use and samples from it and from a tap in the plant show no detectable beryllium.

Organics

Organics in the onsite wells and the wells north of the site have not been compared to background. They have been compared to MCLs and no exceedances were found.

Further comparisons will be done as part of the RI.

Luckey 3.3 Conceptual groundwater fate and transport model

The current conceptual model of groundwater fate and transport is fairly simple. Water percolates slowly from the non-lithified overburden into the bedrock. It also migrates slowly to the north towards Toussaint Creek. Some water from the overburden is discharged to the creek. The groundwater surface in the bedrock dips gently to the north and northeast. Recharge is in part due to the presence of the water filled quarry to the south. The quarry was excavated to at least 70 feet below ground surface. This is roughly 50-60 feet below the current groundwater surface.

During the 1950's, 60's and part of the 70's the quarry was in operation. At that time the groundwater flow direction was reversed with flow from the site to the south.

The affect of the two onsite production wells is unknown at this time although it is assumed that they do affect the local gradient. They are known to be 320 feet deep however so they are drawing from a significant thickness of aquifer and may not affect the near surface water surface significantly.

The hydraulic connection between various parts of the aquifer have not been evaluated. That information will be developed in connection with modeling of the groundwater system which will be a part of the RI.

Luckey 3.4 Adequacy of Information

Information is continuing to be gathered. An evaluation of its adequacy will be done during the compilation of data for the RI.

Painesville

Painesville 3.0 Site Characterization

The Painesville site contains as many as 35 buildings and structures. Available information on the construction and function of most of these buildings is limited.

In the early 1940s, the Defense Plant Corporation constructed a magnesium reduction facility in Painesville, Ohio, on property owned by the Diamond Magnesium Company (DMC). In support of the war effort and later government operations, DMC operated this facility from the early 1940s to the early 1960s for the General Services Administration (GSA). The plant was sold by the GSA in two parts in 1963. At that time, Uniroyal purchased approximately 15.5 ha (38 acres) as commercial property, located at 720

Fairport-Nursery Road (ORNL 1990). Lonza purchased the second portion of the property (ORNL 1991).

Painesville 3.1 Geology and Hydrology

The Painesville site lies within the Eastern Lake Section of the Central Lowland Province, commonly referred to as the Lake Plain. The Lake Plain is a narrow strip of land, three to five miles wide, that parallels the shoreline of Lake Erie. This section consists of sedimentary rock sequences overlain by glacial deposits. The land surface slopes very gently downward to the present lake bluff (White 1980).

The uppermost bedrock unit underlying the site is the Chagrin Shale Formation (Schmidt 1988). The Chagrin Shale is a member of the Late Devonian-aged Ohio Shale Formation. Bedrock was not encountered in any of the boreholes, drilled to a maximum depth of 40 ft, during characterization; however, shale fragments were observed in the overlying soil. These shale fragments are a result of glacial erosion and presumably belong to the Chagrin Shale Formation.

The Ashtabula Till, a nonlithified till deposited in the late Woodfordian Age of the Wisconsinan glaciation during the Pleistocene Epoch, lies disconformably above the Chagrin Shale. Characteristically, the till is a dense, weakly jointed, compact unit with a gray color on fresh surfaces and a brown color where weathered (Schmidt 1988). The till was also observed to have a high clay and silt content with few sand and gravel-sized, dark gray, shale fragments.

Located above the Ashtabula Till at the site is a layer of disturbed/fill material. Borings revealed a thickness ranging from 0.0 to 20.5 ft. This unit was found to be thickest in the western/northwestern part of the site over a large area that extends from the western side of Uniroyal's butadiene tank to their northwestern property boundary. Surface geophysical surveys conducted at the site also confirmed the location and approximate/relative depth of the fill. The fill consists of a wide variety of material: disturbed native till, black coal slag and fly ash, white granular polyvinyl chloride, red bricks, concrete, sand and gravel, plastic, cloth, glass, and metal of various origins.
The primary surface water features on the Painesville site are the Uniroyal and Lonza waste ponds, which are approximately 1.0 and 0.3 acres in size, respectively. According to Uniroyal their waste pond was constructed in 1965 and never received any discharges from MED activities. The only current recharge to this pond is through rainfall and snow-melt. Since the Lonza waste pond was built in recent years, it is unlikely that radiological COCs are present in this pond.

Surface water features near the Painesville site include the Grand River, located approximately 0.1 mile (mi) southwest of Fairport Nursery Road; a waste pond, located between Fairport Nursery Road and the Grand River; and Lake Erie, located approximately 1 mi due north of the property. The Grand River empties into Lake Erie at Fairport Harbor, which is located approximately 1.5 miles northwest of the site.

An extensive storm sewer drainage system is present on the Lonza property and on the eastern half of the Uniroyal property where the ground surface is primarily covered by concrete or asphalt. In these areas, surface water from rain events is quickly captured by the drainage system and ultimately discharged to the Grand River. The western half of the Uniroyal property is covered primarily with grass and has a less extensive storm sewer system.

Elevation data collected from shallow piezometers and temporary monitoring wells suggest that perched groundwater occurs near the surface across much of the site, but is discontinuous and shallow. It appears that perched groundwater is pooling in topographic depressions in the natural clay formation. Observations made during drilling of the deep wells indicated that the materials immediately above the regional groundwater surface were unsaturated over most of their vertical profile. The results from drilling activities determined that the regional water surface is at a depth greater than 40 ft below the ground surface.

Groundwater characterization activities confirmed that the regional potentiometric surface is located more than 40 ft below ground surface and is protected by a clay unit greater than 20 ft in thickness. A discontinuous perched groundwater surface was encountered near the ground surface, as shallow as 1-ft below grade. This perched saturated zone is typically less than 1-ft thick, and was absent in several of the boreholes during the sampling events. Due to the thickness of the silty clay layer which separates the perched zone from the regional water surface, the potential for the vertical migration of COCs to the regional groundwater surface is minimal.

The perched groundwater observed in the piezometers and temporary monitoring wells is very cloudy to turbid in nature and does not represent a potential drinking water aquifer. This determination was made jointly between DOE and the EPA based on the following information obtained during the characterization effort:

- Perched groundwater at the site is typically encountered within the first few feet below ground surface and is perched on top of natural formation soil, which has a high clay content.

- The perched groundwater is discontinuous across the site.

- The thickness of the saturation lens is, in most cases, less than 1 ft.

- Temporary wells installed during characterization activities produced water at very low rates (less than 1 gallon per minute).

According to Aller and Ballou (1991), groundwater yields from the glacial till deposits in Lake County are variable but typically low. Stout et al. (1943) reports that the Chagrin Formation underlying the Painesville area yields little or no water. Sulfur water or brine is often encountered during deep drilling operations, which is evidenced by the Diamond

Alkali Company's solution mining efforts that took place from 1910 to 1977 in the Painesville area.

Slug tests performed within each of the temporary monitoring wells revealed an approximate hydraulic conductivity between 8.5×10^{-5} and 6.5×10^{-6} centimeter/second for the till unit. Both values are characteristic of till as listed by Freeze and Cherry (1979). The hydraulic conductivity for the overlying fill was computed as 2.3×10^{-3} cm/sec which is more representative of silt and sand deposits (Freeze and Cherry 1979). It should be noted, however, that due to the heterogeneous nature of the fill, the hydraulic conductivity values could vary by several orders of magnitude.

Painesville 3.2 Substances Detected at the Site Above Background Levels

Painesville 3.2.1 Substances in Soil

COCs at the Painesville site are limited to radionuclides transported with the scrap iron to the site. Most of the evaluation was confined to comparisons with the sum of ratios (SOR) of each radionuclide to its corresponding guideline as defined by DOE. Of the 356 soil samples analyzed for radiological composition, only 64 samples, collected from 30 boreholes, exceeded the SOR guideline. Sample PNV0685, collected from the 0.5 to 1.5 ft interval of borehole BH0106, showed the highest activity levels at the site. This sample showed an adjusted U-238 and Ra-226 activity of 191 pCi/g and 1010 pCi/g respectively, and a SOR value of 78. The deepest soil sample found to exceed the SOR guideline was collected from the 3.5-ft to 4.5-ft depth interval within borehole BH0042. As expected, the majority of the samples exceeding the SOR guideline were collected from the 0.0-ft to 0.5-ft depth interval.

In comparing the results to background 79% of the samples exceed the background for Ra-226, 86% of the samples exceed the background for Th-230 and 73% exceed the background for U-238. This is not unexpected since the samples were taken by targeting areas identified by the gamma walkover as exceeding the background by a factor of 2.5.

Twenty-three metals onsite exceeded twice background. Most notably copper which exceeds background by a factor of 432 and exceeds twice background in a total of 18 samples. Metals onsite exceeding 10 times background are calcium, copper, lead, molybdenum, silver and zinc. Of the soil samples analyzed for metals, 42 samples collected from 32 boreholes exceeded EPA Region III Soil Screening Levels (SSLs). Arsenic, barium, chromium, nickel, and thallium from onsite samples exceeded the Region III SSL values. The metal with the highest exceedance of its corresponding level was thallium, which was detected in sample PNV0571 at a concentration of 34.6 mg/kg, and exceeded its corresponding level by a factor of 87. Sample PNV0571 was collected from the 1.5 ft to 2.5 ft depth interval from borehole BH0107.

Some of the samples collected for radiological evaluation were also analyzed for the presence of potentially hazardous chemicals. Of the 39 soil samples analyzed for VOCs and SVOCs, 16 samples, collected from 15 boreholes, exceeded EPA Region III RBCs for one or more of the following compounds: benzo(a)anthracene, benzidine, benzo-(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, 1,1-dichloroethene, 1,2-dichloroethane, indeno(1,2,3-cd)pyrene, polychlorinated biphenyls, trichloroethene, 1,1,2-trichloroethane, and vinyl chloride. The chemical with the highest exceedance of its corresponding guideline was 1,1,2-trichloroethane, which was detected in sample PNV0581 at a concentration of 9,600 µg/kg, and exceeded its corresponding guideline by a factor of 960. Sample PNV0581 was collected from the 1.0-ft to 2.0-ft depth interval from borehole BH0004. Sample PNV0116 was collected from the 2.5-ft to 3.5-ft depth interval from borehole BH0F03 and was the deepest sampling interval found to exceed EPA Region III guidelines for VOCs or SVOCs.

Painesville 3.2.2 Substances in Groundwater

No background samples were taken for groundwater so the following discussion revolves around absolute values and comparisons to DCGs or MCLs.

Radionuclides

For the unfiltered groundwater samples, concentrations of U-238 were found to range from as low as 13.2 pCi/L in well TW0010 to as high as 313 pCi/L in well TW0107. These detections of U-238 were well below the corresponding DCG of 600 pCi/L. The highest concentration of Ra-226 in the unfiltered samples was detected in well TW0008 at a concentration of 23.3 pCi/L. Unfiltered concentrations of Ra-226 in the remaining wells ranged from as low as 0.7 pCi/L in well TW0010 to 15.2 pCi/L in well TW0007. These detections of Ra-226 were well below the corresponding DCG of 100 pCi/L. The Ra-226 values do exceed MCLs, but because the groundwater is not considered a potential drinking water source, application of MCL criteria is not applicable to this location. The concentrations of Th-230 in unfiltered samples were found to range from as low as 0.5 pCi/L in well TW0105 to as high as 50 pCi/L in well TW0008. These detections of Th-230 were well below the corresponding DCG of 300 pCi/L. The highest unfiltered concentration of Th-232 was detected in well TW0008 at a concentration of 39 pCi/L. Unfiltered concentrations of Th-232 in the remaining wells ranged from as low as 0.1 pCi/L in well TW0105 to 2.4 pCi/L in well TW0010. These detections of Th-232 were well below the corresponding DCG of 50 pCi/L. The unfiltered concentrations of Ac-227 ranged from 0.2 to 0.4 pCi/L. The Ac-227 concentrations were derived from Th-227 concentrations, which are in secular equilibrium. These detections of Ac-227 were well below the corresponding DCG of 10 pCi/L. The unfiltered concentrations of Pa-231 were all below detection limits ranged from 132 to 230 pCi/L. While these detection limits exceeded the 10 pCi/L DCG, lower detection limits were not attainable because the analysis had to be performed using gamma as opposed to alpha spectroscopy

Painesville 3.3 Conceptual Ground Water Fate and Transport Model

Groundwater characterization activities confirmed that the regional groundwater surface is located more than 40 ft below ground surface and is protected by a clay unit greater than 20 ft in thickness. A discontinuous perched groundwater surface was encountered near the ground surface, as shallow as 1-ft below grade. This perched saturated zone is typically less than 1-ft thick, and was absent in several of the boreholes during the sampling events. Due to the thickness of the silty clay layer, which separates the perched zone from the regional water surface, the potential for the vertical migration of COCs to the regional groundwater surface is minimal. Water in the perched zone is lost either to evapotranspiration or to migration to surface drainage.

Painesville 3.4 Adequacy of Information

Although the information on groundwater at Painesville is adequate to conclude that there is a very low likelihood of FUSRAP material affecting the regional aquifer. The information gathered is not adequate to fully evaluate the groundwater system. No wells were drilled into the regional groundwater system and no background samples were taken. There is also insufficient information to model the potential for migration of contaminants through the silty clay layer to the regional water surface. There is also no background data for the site.

Colonie Interim Storage Site

CISS 3.0 Site Characterization

In 1937 the National Land (NL) Industry purchased Colonie Interim Storage Site (CISS) and surrounding property, including portions of Patroon Lake. "In 1958, the nuclear division of NL Industries began producing items manufactured from uranium and thorium under a license issued by the AEC. NL Industries discontinued its brass foundry operations in 1960. Between 1958 and 1984, NL Industries carried out a number of processes using radioactive materials consisting primarily of depleted uranium but also of thorium and enriched uranium. The plant handled enriched uranium from 1960 to 1972. From 1966 to 1972, NL Industries held several contracts to manufacture fuel from enriched uranium for experimental nuclear reactors. Operations were also conducted at the plant to reduce depleted uranium tetrafluoride to depleted uranium metal, which was then fabricated into shielding components, ballast weights, and projectiles. As a result of NL industries' operations, the site buildings, grounds, and vicinity properties became radioactively contaminated."

The Department of Energy (DOE) has removed approximately 1,200 yd^3 of radioactively contaminated soil from CISS between 1985 and 1988 and it is being stored under a synthetic cover in the main building of the former NL Industries. A Remedial Investigation/Feasibility Study and Environmental Assessment (RI/FS/EA) has been completed to integrate the requirements of the Comprehensive Environmental Response, CERCLA and the NEPA.

CISS 3.1 Geology and Hydrogeology

Unit 1: Fill-gravel, sand, silt, clay, brick rubble, foundry sands, scrap, etc.
(0-21 ft)

Unit 2: Dune Sand-fine to medium grain sand (0-13 ft)
Unit 3: Upper Sand-silty sand to silt, saturated (0-24 ft)
Unit 4: Upper Clay-clay, sandy silt to sand (0-11 ft)
Unit 5: Lower Sand-sandy silt to sand (11-26 ft)
Unit 6: Lower Clay-stiff, breaks along varve partings >101 ft
Unit 7: Glacial till-clay to gravelly clay >3 ft.

There are two aquifers identified as potentially important at CISS, the Pine Bush Aquifer and the Colonie Channel Aquifer. The Pine Bush Aquifer has an upper and lower system associated with it. The upper system consists of saturated portions of the upper sand unit and channel deposits. The lower system comprises saturated sediments in the lower sand unit. The Colonie Channel Aquifer is composed of non-lithified, confined glacial lag deposits (BNI 1992). See CISS Figure 3.1 for a more detailed stratigraphic column.

CISS 3.2 Substances Detected at the Site Above Background Levels

CISS 3.2.1 Substances in Soil

The estimated volume of soil waste on CISS in the 1993 EE/CA was 124,470 yd^3. 165 samples collected from 26 boreholes throughout the burial areas on the CISS show U-238, Ra-226, and Th-232 to have concentrations as high as 530 pCi/g, 45 pCi/g, and 21,000 pCi/g, respectively. The deepest area of subsurface contamination was in the Patroon Lake area at 20 and 21 feet. A study examining the extent of soil contamination under the main building was carried out using 186 samples collected from 36 boreholes underneath and around the foundation of the main building. This soil was also tested for U-238, Ra-226, and Th-232, with values up to 360 pCi/g, 2.0 pCi/g, and 2.1 pCi/g respectively. Only two of the samples exceeded guidelines for uranium (DOE 1995).

Soil collected during the site characterization and analyzed for metals, antimony, cadmium, copper, lead, molybdenum, selenium, thallium, and zinc were all found to exceed the maximum expected background values. All of these elevated metal concentrations were found to be attributed to plant processes or materials used at the plant except for thallium and selenium. VOCs found in excess of their maximum expected background values include 1,2-dichloroethene, 2-butanone, carbon disulfide, ethylbenzene, tetrachloroethylene, toluene, trichloroethylene, xylene.

Results obtained from the RCRA-hazardous waste characteristics tests showed that all of the samples taken in the contaminated area failed TCLP tests for lead (BNI, 1995).

CISS 3.2.2 Substances in Groundwater

Radionuclides

Ten monitoring wells, located in both the upper and lower sand units, were sampled quarterly for U-238, Ra-226, Th-230, and Th-232. None of these constituents exceeded their DOE-derived concentration guidelines.

Metals

Sampling and analyzing groundwater for metals found aluminum, arsenic, iron, manganese, lead, and zinc were sporadically detected above established MCLs.

"Results of metal analysis indicate that aluminum, arsenic, iron, manganese, lead, and zinc were sporadically detected in concentrations above established guidelines. Elevated concentrations of aluminum, iron, and manganese may result from analyses of unfiltered samples. However, zinc was found in elevated concentrations ranging from 854 to 938 µg/L in well B39W19S. Zinc concentrations in samples from wells B39W14S and B39W10S did not differ significantly. The elevated arsenic concentration (172µg/L) was a single observation in well B39W10M, an offsite well. The elevated lead concentration was a single observation in well B39W19S, a well inside the CISS building (DOE 1995)."

Organics

"The analytical results for organic contaminants indicate that the maximum concentrations of benzene (60 µg/L), tetrachloroethene (450 µg/L), 1,1-dichloroethylene (72 µg/L), trichloroethene (61 µg/L), toluene (56 µg/L), and kepone (0.69 µg/L) all exceed federal or state water quality standards. Bis(2-ethylhexyl)phthalate was also present (BNI 1992a).

Results from the most recent annual environmental report indicate that trichloroethane and tetrachloroethane and 1,2-Dichloroethylene were detected in wells B39W07S (BNI 1992b). Concentrations of trichloroethene and tetrachloroethene increased slightly in the second quarter and then decreased in the third and fourth quarters. Concentrations of trichloroethene exceeded the EPA guidelines (5 µg/L) during the first, second, and third quarters. Concentrations of tetrachloroethene exceeded the EPA guidelines (0.7 µg/L) during all quarters. Organic contaminants will continue to be monitored as part of ongoing site investigations (SAIC 1995)."

CISS 3.3 Conceptual Ground Water Fate and Transport Model

CISS has little erosion, most of the site is covered by vegetation, buildings, or gravel. Groundwater flow in the upper and lower sand units flow towards the south with the majority draining to Patroon Creek through a storm sewer.

"Concentration of dissolved contaminants (total uranium, zinc, lead) consistently exceeds background concentrations in well B39W19S, which monitors the upper sand unit beneath the building. The slope of the potentiometric surface downgradient of B39W19S suggests that mobile contaminants in a narrow plume may bypass the downgradient well (B39W10S) by following the path of the Holocene channel and emerging in the stream. However, the particle-reactive nature of the metals further suggests that any offsite migration in groundwater will be slowed by sorption reactions (between dissolved contaminants and silt/clay grains) along the flow path (DOE 1992)."

CISS 3.4 Adequacy of Information

In the 1992 FS, it is stated that more groundwater data is needed from both onsite and offsite locations. "Of primary importance is the need for additional data to resolve questions concerning whether or not chemical contamination from the site has or is currently being transported to offsite locations via groundwater, surface water, or by deposition of contaminants suspended in surface water. Also additional data is required to better define onsite groundwater and resolve questions concerning the potential source, either onsite or offsite, of VOCs contamination reported present in groundwater at the southern boundary of the CISS property.

Shpack Landfill

Shpack 3.0 Site Characterization

"The Shpack Landfill site is a 8-acre abandoned domestic and industrial landfill located in Bristol County, Massachusetts along the Norton/Attleboro town boundary. Initial investigations at the site identified the presence of inorganic and organic chemical contamination and radioactive waste (SAIC 1992)."

In December 1980, Shpack Landfill was included in FUSRAP by DOE; this made DOE responsible for managing radioactive and chemical contaminants resulting from any AEC or MED operations. "In June 1986, pursuant to CERCLA, the U.S EPA listed the site on its NPL. In 1990, an administrative order by consent was executed by several Potentially Responsible Parties (PRPs) and EPA (EPA 1990). Under the terms of the order, the settling parties have initiated a RI/FS of the site to determine the nature and extent of contamination and to develop and evaluate potentially feasible alternatives for remedial action. The settling parties initiated a limited investigation in 1991 (SAIC 1992)."

Shpack 3.1 Geology and Hydrogeology

The Shpack landfill "is located in the Narragansett Basin, a structural and topographic depression containing Late Pennsylvanian age metamorphosed sedimentary rocks. The region was subjected to extensive glaciation during the Pleistocene, followed by deposition glacial till and glaciofluvial deposits of varying thicknesses. Poorly developed post-glacial drainage patterns and topography (kettle terrain) produced swamp deposits and fine-grained soils in low-lying areas (SAIC 1992)."

The Narragansett Basin has been divided into six structural domains. The Shpack Site is located in the Taunton Domain in the northwestern portion of the basin, which is characterized by a series of large-scale east-northeast striking folds (Skehan et al). Despite the influence of bedrock structures may have on surface relief, Pleistocene glacial deposits overlying the bedrock have the dominant influence on topography in this region. A more detailed cross section of the Shpack area along with existing monitoring wells can be found on Shpack Figure 3.1.

Local ground-water production comes from both bedrock and surficial aquifers. Regional structural deformation that produced the east-northeast trending folds in the Rhode Island Formation fractured the local bedrock aquifer, resulting in enhanced secondary porosity or increased hydraulic conductivity this unit. Favorable zones for ground-water flow are in the fracture patterns oriented parallel to these folds (Frimpter and Maevsky 1979).

Geologic mapping indicates a favorable zone for ground-water flow in a fracture system located just north of the Schpack Site. The axis of an anticline is mapped north and parallel to this ground-water flow zone (Williams 1968).

The landfill was developed on what was originally a swamp. The Shpack Site is relatively flat with minor depressions and knolls. A wetland area lies immediately within the northeastern fenced border area and other areas of the site contain standing water and wetland vegetation seasonally. Chartley Swamp, which generally bounds the site in every direction, consists of more extensive low lying wetland areas. The Attleboro Landfill, Inc. landfill lies to the south of Shpack. This landfill is comprised of waste materials deposited in former wetland areas and rises approximately 100-ft above the surrounding ground surface (ERM 1993). Chartley Pond, a manmade reservoir, bounds the Shpack Site on the north. Chartley Brook, which flows north into Chartley Pond, is located west of the Shpack Site beyond the Attleboro landfill (SAIC 1992).

Surface water at the site drains into Chartley Brook and Chartley Pond to the east and north, respectively. Surface drainage is primarily southward to the swamp. The flow direction in the swamp is thought to be primarily northward. Observations at the site indicate the fill to be poorly drained, suggesting low permeability (Cottrell et al. 1981). Evidence for the extent of the 100-yr floodplain suggests the original topography at the site included a drainage swale near the middle of the site. Such a swale could influence both surface and subsurface flow and direct it south to Chartley Swamp (Cottrell et al. 1981).

The site stratigraphy consists of landfill materials, organic rich soil, and glacial deposits overlying bedrock. The uppermost naturally occurring materials onsite are organic rich soils. They range in texture from sandy organic soils in elevated, well-drained areas to peats in low-lying areas, poorly drained areas. The peats reach a thickness as much as 11-ft in the adjacent Attleboro landfill to the west (SAIC 1992). However, it is thought that only a thin layer of peat separates the fill material from underlying glacial deposits. The native soils at the site have been covered by a variety of landfill materials including waste from industrial sources, construction debris, and mineral soil fill (Cottrell et al. 1981).

Glacial deposits that range in thickness from 15 to 36-ft overlie the bedrock at the Shpack Landfill. The lithofacies described within this stratigraphic interval are till and outwash (glaciofluvial) deposits. Several distinct till units have been described including tight sandy clay and clayey sand till. Outwash deposits have been described as brown to gray, fine- to coarse-grained, silty, gravelly sands. Around the perimeter of this site, cobbles, boulders, and thin layers of clay, silt, and pebbles are present in this unit (SAIC 1992).

The Rhode Island Formation is the bedrock unit present at the site. Lithologies described in the bedrock unit during well installation are interbedded metamorphosed sandstone, siltstone, and conglomerate. The bedrock was described as bluish-gray to dark gray, moderately hard, brittle, and highly fractured (SAIC 1992).

Ground water exists in both the non-lithified glacial deposits and the bedrock unit onsite (SAIC, 1992). "Groundwater flow in the bedrock is dominated by flow through fractures, which are numerous in the shallow subsurface and diminish in size and number with increasing depth (GHR Engineering Associates, Inc. 1985)." Depth to the water surface is generally 5-ft or less (Cottrell et al. 1981). Water level measurements in wells did not vary significantly, whether in glacial materials or bedrock, indicating the overburden and bedrock are interconnected (BNI 1984).

Ground-water studies conducted as part of the RI for the site have determined the direction of ground-water flow at the site is predominantly downward, through the overburden, with the dominant lateral component of flow in the deep overburden and upper bedrock toward the southeast in the direction of Chartley Swamp (ERM 1993). Offsite groundwater sampling (Cottrell et al 1981, BNI 1984) has identified no elevated activity levels of radionuclides.

Shpack 3.2 Substances Detected at the Site Above Background Levels

Shpack 3.2.1 Substances in Soil

"The primary contaminants found at the site were radium-226, uranium-238, uranium-235, and uranium-234. The uranium is in depleted, natural, and enriched forms. Compared to natural background for the region, elevated concentrations of radium-226, uranium-238, uranium-235, and uranium-234 were found in surface and subsurface soils. Maximum concentrations were 1571 pCi/g for radium-226, 16,460 pCi/g for uranium-238, 200 pCi/g for uranium-235, and 4200 pCi/g for uranium-234. These concentrations are below background levels and are nonuniform across the site, containing numerous hot spots (BNI 1984)(SAIC 1992)."

Shpack 3.2.2 Substances in Groundwater

Radionuclides

Seven monitoring wells were analyzed and only one found concentrations of radioactivity above background levels, the wells also showed no migration of radionuclides off site (SAIC 1992).

Shpack 3.3 Conceptual Ground Water Fate and Transport Model

Water levels vary little in the wells at Shpack, this indicates that the overburden and bedrock are interconnected. Areas with thick peat moss make contaminant transport to bedrock limited. Groundwater flow through the bedrock takes place mostly through fractures, decreasing in size and number with depth. Although data on the flow of groundwater in the bedrock is limited, it suggests a slight upward vertical gradient toward local surface water discharge points (SAIC 1992).

"Water level measurements in glacial aquifer boreholes suggest that a potentiometric high existed in the center of the landfill with radial flow to discharge points in the surrounding low-lying and sqampy areas. Evidence for the extent of the 100-yr floodplain suggests the original topography at the site included a drainage swale near the middle of the site. Such a swale would serve to focus both surface and subsurface drainage and direct it south toward the Chartley swamp. Horizontal gradients in the glacial material tend to be extremely low (on the order of 0.0006 ft/ft) (SAIC 1992)."

Shpack 3.4 Adequacy of Information

A number of issues have not yet been addressed in characterization of groundwater at the site, these issues are discussed in the 1992 Site Characterization Plan. Groundwater studies were conducted as part of the RI. ERM-New England completed several tasks outlined in the work plan (SAIC 1992). These tasks included a soil gas survey, geophysical investigations, test pit excavations, and the installation of microwells (ERM 1993). The items below will not be determined completely until the ERM document is reviewed, there may be questions concerning the following:

- Ground-water flow characterization.
- Radiological and chemical background data for COC
- Characterization of hazardous waste or polychlorinated biphenyls (PCBs) within the radioactive waste
- Characterization of inorganic and organic contaminants on the site
- Extent of contamination

W.R. Grace

W.R. Grace 3.0 Site Characterization

The W.R. Grace & Co., Davison Chemical Division, Curtis Bay Facility presently occupies approximately 90 acres located on an industrialized peninsula in south Baltimore, Maryland. Curtis Bay borders the property on the north. Curtis Creek borders the property on the west. The Patapsco River forms the western border while the southern border is formed by the Baltimore Municipal Landfill. Documented radioactive materials processing began in July 1955 when Rare Earths, Inc., the predecessor to Grace, entered into contract with and was licensed by the Atomic Energy Commission to process approximately 7900 tons of monazite sand to recover thorium. An approximately

170-acre section south of the present site was formerly part of the Grace facility but was condemned by the city of Baltimore in the mid-1980s for use as a municipal landfill.

The monazite sand was obtained from domestic and foreign sources. The monazite sand was received and stored at a General Services Administration depot, located 1 mile south of the site, and was transported by truck to the Grace site for processing. The processing involved size reduction, acid leaching, crystallizing, and releaching to extract the thorium from the monazite sand. The processing did not prove successful and was, therefore, terminated after only about 8 months of trials and after processing about 1000 tons of monazite sand.

During and subsequent to the processing, residuals from the process, referred to as gangue, as well as associated equipment and debris were buried in pits in a 4-acre area known as the radioactive waste disposal area. This 4-acre disposal area is the subject of this evaluation. The interior of the building where the processing was performed was also contaminated but the dry nature of the media (monazite sands) makes it unlikely that the ground water in this area was contaminated.

W.R. Grace 3.1 Geology and Hydrogeology

Underlying W.R. Grace are non-lithified materials of the Potomac Group of Late Cretaceous age, part of the sedimentary sequence that makes up the Atlantic Coastal Plain geologic province. The upper portion, approximately 250 feet of the Potomac Group, consists of irregularly distributed beds of sand, gravel, sandy clay, and clay collectively referred to as the Patapsco Formation, which is underlain by the Arundel Clay and Patuxent Formation. The Patapsco Formation supplies water for industrial uses in Baltimore and for drinking purposes in the towns of Annapolis, Glen Burnie, Odenton, Forest Heights, Indian Head, and Bowie. Depth to groundwater at the Grace site is estimated to range from 5 feet near the northern boundary with Curtis Bay to approximately 25 feet at the southern site boundary and is likely to be subject to tidal influences. Groundwater flow is generally northward discharging to Curtis Bay, with a regional hydraulic gradient of 1.2×10^{-3} inches/sec. Fill material is common along Baltimore's industrial shoreline, ranging from approximately 5 to 25 feet at the site.

W.R. Grace 3.2 Substances Detected at the Site Above Background Levels

W.R. Grace 3.2.1 Substances in Soil

Data are very limited on the Grace site. Only preliminary site assessment type investigations have been performed. No groundwater investigations have been performed. No investigations of the nearby sediment or Curtis Bay areas have been done.

The COCs for removal are primarily thorium and its daughter elements. Thorium is a component of monazite sands and was the target element for the processing at Grace. Contamination is present because the process did not remove all of the thorium from the sand. In addition, contaminated process equipment and other related wastes, such as filters, were reportedly buried in the RWDA. Uranium and other contaminants are likely present but at lower concentrations than thorium.

Gross gamma activity across the disposal area was measured in 1978. Surface radiation measurements ranged from background levels to 17 mrem/hour. Radiation across the surface of the disposal area was found to be randomly dispersed. Five boreholes were drilled to assess vertical and horizontal dispersion of radioactive material. Twenty-one samples were taken at various depths and different strata to characterize the vertical profile of the deposit area. Radioactive material is dispersed in multi-colored fine to coarse sand and industrial waste zones. The results indicated that the radioactive material is not uniformly deposited throughout the site. No vertical or horizontal concentration gradient could be defined which indicated that the waste materials are insoluble and immobile

Data does not exist for metals and organic compounds in soils at the W. R. grace site.

Data does not exist for contaminants in the sediments surrounding the RWDA.

W.R. Grace 3.2.2 Substances in Groundwater

Data do not exist for radionuclides, metals or organic contaminants in groundwater at the W. R. grace site.

Combustion Engineering (CE)

CE 3.0 Site Characterization

The Combustion Engineering (CE) facility consists of approximately 600 acres in the area of Windsor, Hartford County, Connecticut. Currently there are more than 30 buildings on the property used for nuclear and fossil fuels research and development, nuclear power plant support, engineering and designing activities, administration, materials storage, and general property and equipment maintenance (SAIC 1998).

Activities involving nuclear research and development, and fabrication of nuclear fuel for the U.S. Navy commenced in 1955 under a contract to the AEC. Activities under this contract also included the construction, testing, and operation of the S1C facility. AEC manufacturing and research development activities for Naval nuclear fuel were terminated in 1961. CE continued to operate the facility until 1970. After 1970, the S1C facility continued to operate as a pressurized water naval nuclear propulsion plant for training, research, and development under the name of Knolls Atomic Power Laboratory, Inc. under the jurisdiction of DOE. The S1C facility was permanently shutdown in 1993 and is currently being decommissioned by the DOE Office of Naval Reactors (SAIC 1998).

In 1997, Congress transferred responsibility of FUSRAP to the USACE. Thc USACE New England District is planning to characterize the FUSRAP areas at the CE site to obtain data adequate to evaluate remedial alternatives for these areas (SAIC 1998).

CE 3.1 Geology and Hydrogeology

The CE Windsor Site is located within the Central Valley landscape of the Newark Terrain in Connecticut. Bedrock underlying the site consists of a sequence of clastic sedimentary rocks interlayered with igneous rocks associated with the Newark rift basin. The bedrock formation underlying the site is the Portland Arkose, which consists of reddish-brown arkosic siltstone, with some reddish-brown arkose beds of unknown thickness (Schnabel and Eric 1964). The Portland Arkose strikes north-northeast and dips eastward typically at 10 to 15 degrees. Underlying the Portland Arkose is the Hampden Basalt, a medium-to -fine grained, medium dark gray to dark greenish-gray basalt approximately 100 to 150 feet thick. Three arkosic units with two interlayered basalt formations are found below the Hampden Basalt. The bedrock surface in the region has been formed into generally north-south trending hills and valleys SAIC 1998).

Based on available subsurface information, depths to bedrock at the CE Site range from 90 feet just west of the southwest corner of the site; to roughly 125 feet in the south-central part of the site near Buildings 24 and 25; to at least 144 feet in the southeast part of the site. Bedrock was primarily identified as reddish-brown shale with some red sandstone present (SAIC 1998).

The surficial geology of the site consists of an estimated 10 to 15 feet of compact glacial till underlain by coarser sand and gravel deposits. The thickness of a fine sand unit varies from roughly 20 to 50 feet, and its surface ranges from 20 to 40 feet below grade. This fine sand unit apparently thins and becomes deeper to the north where it terminates on, and intermingles with, coarse-grained, ice-contact deposits underlying the northern and eastern borders of the site. Geologic logs indicate that the north central portion of the site is primarily underlain by fine sands with varying amounts of coarse sand, silt, and gravel in the shallow subsurface. A general coarsening downward stratigraphic sequence is evident at the site. Soils, which developed on these deposits, have been mapped as the Merrimac Series, which is described as a well drained to excessively drained moderately coarse-textured soil (USACE 1998).

Local hydrogeologic conditions have been determined from data gathered from monitoring wells installed at the site. Geologic and aquifer test data suggest that two overburden aquifer systems underlie the site: (1) an upper mostly fine-grained unconfined aquifer on the east side of the site, and (2) a lower, coarse-grained semi-confined aquifer. Depth to the water surface in the areas monitored is typically 27 to 41 feet below grade. Ground-water flow in the upper aquifer is typically north toward the Farmington River. Locally, shallow ground water is diverted toward bodies of surface water. Ground water is diverted to the northeast near Goodwin Pond and the Site Brook.

Results of aquifer tests at the site show a range of hydraulic conductivity from approximately 1×10^{-3} to 1×10^{-4} cm/sec. Hydraulic gradients in the shallow aquifer are approximately 0.01, resulting in an estimated ground-water flow rate of 1 to 10 feet per year (SAIC 1998).

According to the Water Quality Classification of Connecticut map (SAIC 1998), ground water beneath most of the site is designated as GA. This identifier defines the waters as suitable for existing and potential private and public water supplies that are presumed to be of sufficient quality for direct human consumption without treatment. Ground water beneath a small portion of the site property is classified as GB/GA, which defines this water as possibly not being suitable for direct human consumption due to waste discharges, spills, or leaks of chemicals or other land use impacts. The state of Connecticut's ultimate goal is to restore the ground water to drinking water quality (SAIC 1998).

CE 3.2 Substances Detected at the Site above Background Levels

CE 3.2.1 Substances in Soil

Soil and sediment investigations at the CE Site have concentrated on radionuclides. In 1993, DOE had the Oak Ridge Institute for Science and Education (ORISE) conduct a radiological survey over portions of the CE Site that confirmed highly enriched uranium (HEU) was present in areas within Building 3, the grounds north of Building 3, the Waste Storage Pad, the Drum Burial Pit, the Site Brook and its associated bank, and the sanitary and industrial drainlines (SAIC 1998).

The FUSRAP designation survey of 1994 was conducted as a preliminary investigation to identify portions of the CE site for which the federal government would have authority for taking remedial actions.

In the summer of 1996, DOE requested that ORISE re-evaluate the current radiological conditions at the CE site based on an additional review of the existing data. The objective of the re-evaluation was to provide updated information on the radiological conditions of the CE site relative to U with an enrichment of not less than 20 percent in the U-235 isotope. The re-evaluation performed by ORISE in 1996 confirmed the results the 1993 survey. During this re-evaluation, U contamination in the Site Brook was further characterized using a data set of over 121 sediment samples collected from the Site Brook in 1991 by DOE naval reactor facility personnel (SAIC 1998).

In April and May of 1998, the USACE performed a gamma walkover survey (GWS) of the areas around Buildings 3 and 6, the Waste Storage Pad, the Drum Burial Pit, and areas along the Site Brook.

Six soil samples collected from five locations within the area north of Building 3 revealed U-235 activity levels ranging from less than 0.1 to 148 pCi/g, with an average of 36.92 pCi/g. U-238 activity levels for these samples ranged from less than 1.7 to 12 pCi/g, with an average of 6.2 pCi/g. Total U activity levels ranged from less than 5.20 to 3,700 pCi/g, with an average of 860 pCi/g. U-235 enrichment ranged from less than 0.57 to 74 percent, with an average of 27 percent. Alpha spectrometry analyses performed on two of these samples measured total U concentrations of 39.1 and 768 pCi/g with enrichments of 3.7 and 36 percent, respectively (Abelquist and Gibson 1994).

The GWS conducted over the area surrounding Buildings 3, 3A, and 6 identified elevated radioactivity to the immediate north, east, and south of Building 3, to the immediate north of Building 6, and along the fence between the buildings. Areas of elevated activity were detected using Field Instrumentation For Detecting Low-Energy Radiation (FIDLER). Radiation was detected at levels ranging from 10,000 to greater than 200,000 counts per minute (CPM) (SAIC 1998).

Surface scans of the twelve randomly-selected 30-foot grid blocks performed by ORISE in 1994 found that 10 of the 12 grid blocks exhibited elevated direct gamma radiation. Twenty-five soil samples collected within the Waste Storage Pad area contained U-235 concentrations which ranged from less than 0.1 to 2,169 pCi/g with an average of 169 pCi/g. U-238 activity levels ranged from less than 0.27 to 72 pCi/g, with an average of 7.8 pCi/g. Total U activity levels ranged from less than 4 to 54,000 pCi/g, with an average of 4,300 pCi/g. Percent U-235 enrichment for these samples ranged from less than 0.8 to 86 percent, with an average of 44 percent (Abelquist and Gibson 1994).

The GWS over the Waste Storage Pad identified elevated radioactivity just inside the snow fence along the road that divides the site and adjacent to the asphalt pad. The areas of elevated activity detected using the FIDLER are shown on Figure 1-7. Radiation was detected at levels ranging from 10,000 to greater than 200,000 CPM (SAIC 1998).

In October 1990, Integrated Geosciences of Salem, Massachusetts performed an electromagnetic (EM) survey and a magnetometer/gradiometer survey over the area of the Drum Burial Pit. Both geophysical surveys were conducted on a 150 ft by 180 ft grid established on 10 ft centers. The two complementary surveys indicated an area of concentrated metallic material approximately 2,000 ft^2 in size. Based on visual observation of the study area, it was noted that the readings are expected to be from the presence of buried drums, however, other types of discarded metallic material could yield similar results. Several smaller areas of metallic materials were also indicated by the EM survey, but did not respond well to the magnetometer/gradiometer survey (GZA GeoEnvironmental, Inc. 1991).

Previous DOE sampling has indicated the Drum Burial Pit area contains HEU material (Abelquist 1996). In 1990, CE personnel performed a small excavation in the southern half of the burial pit area (SAIC 1998). During this excavation 26 barrels were exhumed and their physical condition characterized. From this excavation it appears the Drum Burial Pit extends approximately 15 ft below ground surface and material was placed in no particular order. Material encountered in this excavation included: small piping, electrical wiring, plastics, considerable soil and sand, tools, vermiculite, fiberglass insulation, paint cans, conduit, chicken wire, anti-COC clothing and asbestos (SAIC 1998). Gamma readings at the base of the excavation ranged from 0.01 to 2 milliRoentgen/hour (mR/hr). Surveys on the exterior surfaces of the exhumed barrels ranged from background to over 180 times background [2,200 counts per minute (cpm) to 400,000 cpm (SAIC 1998)].

Seven soil samples were collected from six locations within the Drum Burial Pit. Sample number 5 was taken from inside an excavated drum. Elevated direct radiation was found only within the excavation and near a tree. U-235 activity levels in the seven soil samples ranged from less than 0.1 to 620.1 pCi/g, with an average of 103 pCi/g. U-238 activity levels ranged from less than 0.48 to 20.6 pCi/g, with an average of 4.9 pCi/g. Total U activity levels ranged from less than 3.6 to 16,000 pCi/g, with an average of 2,700 pCi/g. Percent U-235 enrichment for these samples ranged from less than 1.4 to 82, with an average of 48 percent. A buried piece of plastic found adjacent to soil sample 2 contained a U-235 activity level of 307,400 pCi/sample and a U-238 activity level of less than 19,000 pCi/sample (Abelquist and Gibson 1994).

The GWS conducted at the drum burial pit area detected small amounts of elevated radioactivity inside of the snow fence immediately adjacent to the excavation and east of the site access road. Radiation was detected at levels ranging from 10,000 to 49,000 CPM(SAIC 1998).

In 1991, personnel at the DOE naval reactor facility collected 121 sediment samples within the Site Brook. The primary analyte of interest was cobalt (Co)-60. In 1996, ORISE's Environmental Survey and Site Assessment Program reanalyzed these samples to provide information on total U concentrations and enrichment. All samples were analyzed using gamma spectroscopy. In addition, twenty-two of these samples were also analyzed by alpha spectroscopy to determine the U-234 concentration. Elevated activity was found along the stream bank throughout its length and in the stream-bed along the upper half of the brook. Three soil samples were also taken in the area of the debris piles on the bank near the Sewage Treatment.

U-235 activity levels from the Site Brook samples ranged from background to 40.1 pCi/g, for an average of 2.24 pCi/g. U-238 activity levels ranged from less than 0.26 to 24.4 pCi/g, for an average of 3.3 pCi/g. Total U activity levels ranged from background to 1,040 pCi/g, for an average of 60.5 pCi/g. Percent U-235 enrichment from these samples ranged from 0 to 66.1 percent, for an average of 6.44 percent.

The average Co-60 concentration in the Site Brook samples, decay-corrected to the time the samples were collected is approximately 2.2 pCi/g. The maximum and minimum concentration of Co-60 measured in the Site Brook sediment was 47 pCi/g and less than the minimum detectable activity (MDA) which ranged from <0.31 pCi/g, respectively. The activity of Co-60 decreases as you move further downstream from the Windsor Site outfalls. Also, the Co-60 concentrations are, on average, higher in the top layer of sediment (0.0 to 0.5 feet).

CE 3.2.2 Substances in Groundwater

Radiological constituents comprise the primary constituents of concern. USACE has the authority to address chemical constituents when they are commingled with FUSRAP radiological constituents. The activities conducted and the wastes stored at the Waste

Storage Pad and the Drum Burial Pit are not known. Potential COCs at the study areas include metals, TPH, PCBs, asbestos, VOCs, and SVOCs according to CE. Six on-site wells were sampled for radionuclides in 1991 (SAIC 1998).

Radionuclides

The results of historical investigations have identified Uranium (U) and Cobalt (Co)-60 as the primary radiological COCs at the site. The USACE has authority for cleanup if U-235 is enriched at levels greater than or equal to 60 percent (SAIC 1998).

The results of the June 1991 ground-water sampling from six wells showed background radioactivity levels. The gross alpha and gross beta activity levels for these wells ranged from less than 1.4 pCiL to 6 pCi/L, and less than 1.5 pCi/L to 2.3 pCi/L, respectively. The concentration of total U ranged from 0.001 to less than 1.0 mg/L (SAIC 1998).

Metals

Metals were used at the CE Site as a part of the historical processes. CE used mercury and acids in the laboratory portions of Building 3 (SAIC 1998). Since the activities conducted and the wastes stored at the site are not known, other metals could be determined to be COCs by additional investigations (SAIC 1998).

Organics

Both VOCs and SVOCs have been determined to be potential COCs at the CE Site (SAIC 1998). Ground-water data indicate elevated levels of PCE and TCE both beneath and downgradient of the Waste Storage Pad. PCBs have been determined to be potential COCs at the CE Site (SAIC 1998).

Inorganics

Asbestos has been determined to be another potential COC at the CE Site (SAIC 1998).

CE 3.3 Conceptual Groundwater Fate and Transport model

A site conceptual ground-water fate and transport model has not been developed at his time because of insufficient data.

CE 3.4 Adequacy of Information

CE has determined the pre-existing ground-water monitoring wells are inadequate for characterizing ground water at the CE Site. This judgement is based on lack of records concerning the construction and materials used for these wells. Since the transfer of FUSRAP, the USACE has gained responsibility for ground water issues. USACE has proposed a draft SAP for further soil and ground water characterization. CE has installed new monitoring wells on site during 1999. Before any new sampling activities take place, the results from the new monitoring wells will have to be reviewed.

E. I. DuPont, Deepwater New Jersey

DuPont 3.0 Site Characterization

DuPont 3.1 Geology and Hydrogeology

No information is available on the geology and hydrogeology at the Deepwater Site

DuPont 3.2 Substances Detected at the Site Above Background Levels

DuPont 3.2.1 Substances in Soil

Uranium was the principal contaminant found during the two investigations performed.

Six surface soil samples (0-6 inches) were collected during a 1983 investigation with concentrations of U-238 ranging from 2.3 to 7,398 pCi/g.

One hundred ten (110) out of the 127 subsurface soil samples collected had concentrations of U-238, which exceeded the maximum U-238 concentration of 4 pCi/g, found in the background area. The maximum U-238 concentration detected in the subsurface soil samples was 20,810 pCi/g. This sample was located 6-10 inches below a building floor slab. The majority of the U-238 contamination appears to be located at depths of 6 to 36 inches below the surface however; contamination was detected by downhole gamma logging at depths greater than 9 ft.

DuPont 3.2.2 Substances in Groundwater

Radionuclides

Thirty-six groundwater samples were collected during a 1983 investigation. The total uranium concentration ranged from 1.5 pCi/L to a maximum value of 105,105 pCi/L in a groundwater sample collected beneath an existing building.

Metals

No analytical results for metals are available for the groundwater at the Deepwater site. Hazardous constituents are expected to be present in the groundwater and soils as the site has been used to manufacture organic chemicals.

Organics

No analytical results for organics are available for groundwater at the Deepwater site however, the hazardous constituents are expected to be present in the groundwater and soils as the site has been used to manufacture organic chemicals.

DuPont 3.3 Conceptual Ground Water Fate and Transport Model

Current information is inadequate to determine a conceptual groundwater fate and transport model for the Deepwater site.

DuPont 3.4 Adequacy of Information

Two investigations have been performed at the Deepwater site: one by the Oak Ridge National Laboratory in 1977, the other by Bechtel National Incorporated in 1983. The ORNL survey was performed to characterize the existing site radiological conditions. The BNI investigation was performed to confirm the locations of the contamination. These surveys do not delineate the nature and extent of the hazardous constituent contamination or the boundaries of the radiological contamination.

4.0 Important Ground Water Resources at FUSRAP Sites and Levels of Contamination

Table 4.1 summarizes the potentially useable ground water resources on a site-by-site basis. It provides a brief overview of whether each system is currently impacted and the potential for future contamination.

Table 4.1 Important Ground Water Resources at FUSRAP Sites						
Site	**Potentially Useable Groundwater Resource**	**Contaminants Detected in Groundwater Resource**	**Potential for Future Contamination**	**Comments**	**Tentative Aquifer Classification**	**Background Data?**
St. Louis District						
SLDS & VPs	Alluvial Aquifer	No	Yes, slow to moderate leaching		-A Unit (Lower nonlithified) not Considered an aquifer or a source of drinking water -B Unit or Mississippi River Alluvial Aquifer Principal aquifer in St. Louis -C Unit, Limestone Bedrock Lithified, water-bearing unit	No, in the process
SLAPS/HISS & VPs	Post-Maquoketa Aquifer	No	small		-Upper Zone (Unit 1, 2, and 3T) -Middle Zone (3M), Interpreted as an aquitard -Lower Zone (3B and Unit 4) Lowest hydraulic conductivity of Unit 3	Some, in the process of getting more
New York District						
Maywood	Passaic Formation	Metals, possible organics	Yes	-Possible continued impact to the river & shallow/deep bedrock aquifers downgradient and along strike	-Shallow system Occurs in the unconsolidated sediments and Passaic Formation Occurs under unconfined, potentiometric surface, and partially confined conditions No major confining layers have been identified	Needed
Middlesex	Passaic Formation	Primarily uranium, radium, thorium, metals, and VOCs	Yes	-Possible continued impact to stream and shallow/deep bedrock aquifers downgradient and along strike -Water flows to the south	-Shallow Zone Low flow velocity Low hydraulic gradient Flow influenced by a leaky storm water conduit -Deep Zone Higher flow velocity High hydraulic gradient Calcareous zones and solution cavities observed	Needed
Wayne	Buried Valley Aquifer, Boonton Formation	Uranium, radium, thorium, metals	Yes	-Possible continued impact to stream and shallow aquifer and deep bedrock	-Shallow system fluvial/alluvial, unconsolidated material above a confining clay layer -Deep system	Needed

Site	Potentially Useable Groundwater Resource	Contaminants Detected in Groundwater Resource	Potential for Future Contamination	Comments	Tentative Aquifer Classification	Background Data?
				-Areas where the clay layer is absent may allow communication between systems	unconsolidated sediments	
Buffalo District						
Luckey	Lockport Dolomite	Unknown	Yes	-Study and monitoring ongoing. Modeling is needed.		In the process
Painesville	Ashtabula Till	Potentially radium, uranium, thorium.	small	-No samples from useable aquifer.	-Perched groundwater occurs near the surface across the site but is discontinuous and shallow Pools in topographic depressions in the clay formation -Regional groundwater system is located under the clay formation	Needed
Tonawanda: Ashland, Linde, Seaway	Cammillus Shale	Sodium, sulfate, chloride	small		Zone 1: Unconsolidated glacial till and glaciolacustrine clay Zone 2: Soluble limestones and dolostones that surround the third zone Zone 3: Camillus Shale Most important-defined as an aquifer, extremely high conductivity Contains layers of lime mud and gypsum	Needed
Niagara Falls Storage Site NFSS	No information					
New England District						
Combustion Engineering	Local non-lithified aquifers (two	Uranium, Co-60, possible metals,	Yes, extent of contamination has not yet been	-Possible continued impact to an area the State has determined	Overburden aquifers: -Upper-unconfined aquifer on the east side of the site	Needed

	defined on-site)	organics	defined	to be drinking water quality	-Lower-semi-confined	
Site	**Potentially Useable Groundwater Resource**	**Contaminants Detected in Groundwater Resource**	**Potential for Future Contamination**	**Comments**	**Tentative Aquifer Classification**	**Background Data?**
Baltimore District						
Shpack	Glacial deposits and fractured bedrock aquifer	Radionuclides above background level, Possible RCRA waste or organics	Yes, leaching	-Inadequate characterization and understanding of the system	-Surficial unconsolidated glacial deposits non-lithified -Bedrock unit flow is dominated through fractures	Needed
Colonie	Pine Bush Aquifer Colonie Channel Buried-Valley Aquifer	Toluene, kepone, benzene, PCE, TCE, 1,1-dichloroethylene, zinc, lead, Arsenic	Yes, leaching	-Detected organics may be attributed to degreasers and cleaners used on site -Groundwater flow in the Pine Bush Aquifer is towards Patroon Creek	-Pine Bush Surficial sand aquifer Unconfined conditions -Colonie Channel buried-valley aquifer Confined conditions Water flows at Ground surface Discharge occurs by upward leakage through the lacustrine silt and clay deposits, by seepage into Shaker Creek, by flow into permeable zones within the Mohawk River floodplain deposits, and by pumping water-supply wells -Snake Hill Shale Aquifer Recharge, discharge, and groundwater flow relationships not well understood Discharge may occur from upward seepage through this confining layer	Yes
WR Grace	More data needed					
Philadelphia District						
DuPont	More data needed					

Note: The aquifer classification is tentative, it is in the process of being classified into EPA guidelines and will be for the final version of this document.

Table 4.1 shows that FUSRAP will have to address impacts to important ground water resources at a number of sites. Generally, the contaminants are metals (particularly radionuclides) that occur at fairly low concentrations (when compared to tap water standards established by the EPA) in the important ground water systems. The Colonie site is a notable exception where several significant organic compounds contaminate the Pine Bush Aquifer.

At this time, we are not aware of any impacted groundwater users, only some major aquifers which are impacted at very low levels. However, many of the aquifers are not fully characterized, leaving some uncertainty.

Section 5.0 Remediation Technologies

It should be recognized that removal of contaminant sources by excavation is frequently a viable, cost effective technique that may be used to eliminate or reduce the impacts to ground water resources. The following technologies introduce a few of the possible techniques that may be used instead of or in conjunction with source removal. There are new remediation techniques continually being developed, some of which may be worth evaluating and possibly using in the future. However, due to the site-specific nature of the discussion of site remediation and the involvement of numerous stakeholders, the Districts should have the responsibility of selecting the appropriate remedial measures to be taken.

TREATMENT WALLS

Description:
A trench is dug across the flow path of contaminated groundwater and filled with a variety of materials. There are two criteria by which materials are selected to fill the trench. First, the filling must be sufficiently porous and permeable so that it creates a preferred pathway for groundwater. When this criterion is met, groundwater enters the trench and its flow is redirected along the axis of the trench. Second, the filling must be reactive so that the contaminants are effectively removed from the groundwater that flows through the trench. Many times, the filling consists of several different materials which, when combined, optimizes flow, reactivity, and cost effectiveness. For example, sand, which is not reactive, is often mixed with the reactive medium to optimize the trench's permeability to groundwater. The proper proportion of sand to reactive medium is a balance between how permeable the trench must be to redirect groundwater flow and how much reactive medium is needed to meet groundwater remediation goals. Some materials are so reactive that the addition of sand or other porous medium has a negligible effect on the reactive medium's ability to clean the groundwater. In such instances, the addition of sand also is a cost-saving measure as reactive media typically are volumetrically more expensive than sand.

Types of Reactive Media:
The particular type of reactive medium used in a treatment wall depends on the groundwater contaminant being addressed and on the physical (e.g., pH, oxidation-reduction potential) and chemical (e.g., other dissolved chemicals not being addressed) properties of the groundwater. Reactive media perform their function in a treatment wall through different chemical process: sorption, precipitation, and degradation. Those that operate by sorption and precipitation can be most useful for addressing groundwater contaminated by metals and radionuclides. Those that operate by sorption or degradation can be most useful for addressing groundwater contaminated by organic compounds.

Sorption media physically grab contaminants out of the groundwater and hold them on their surfaces. Some examples of sorption media are zeolites, ferric oxyhydroxides, activated carbon, peat moss, and synthetic resins (e.g., DOWEX ®). These media may be used subsequent to an excavation and effectively complement the removal of contaminant sources.

Precipitation media alter the physical and chemical conditions of the groundwater thereby allowing the dissolved contaminants of interest to precipitate as solids. For example, lead can be made to precipitate from lead-saturated battery acid dissolved in groundwater by running the groundwater through limestone which raises the pH of the system. Or, dissolved uranium will precipitate from groundwater when run through iron filings. This is an oxidation/reduction reaction in which the iron is oxidized and the dissolved uranium is reduced so that it precipitates as a uranium hydroxide or uranium carbonate, depending on the composition of the groundwater.

Degradation media optimize conditions under which organic compounds degrade into harmless products. Such media may consist of nutrients that stimulate naturally occurring microorganisms to use a hydrocarbon in groundwater (e.g., TCE or benzene) as an energy source. Addition of a strong oxidizer such as oxygen or permanganate to groundwater will also degrade many hydrocarbons. Iron filings also make good degradation media especially for chlorinated solvent. Oxidation of the iron results in a contaminant reduction of the solvent. This reduction involves stripping of chloride ions from the organic compound ultimately degrading the compound into a harmless chemical (e.g., carbon dioxide).

Cost:

The initial cost of a treatment wall can be relatively high and depends on the length, depth and thickness of the trench to be excavated. However, because a treatment wall is a passive treatment system requiring only periodic monitoring to ensure that the desired goals are being met and, in some cases, replacement of the reactive media, the long term costs are far less than other treatment systems such as pump and treat.

FORAGER SPONGE ®ADSORPTION TECHNOLOGY

Description:
The FORAGER sponge ® is a porous open-celled sponge with a volume of about one cubic centimeter. The sponge contains a specialized polymer with selective affinity for certain metals and other inorganic elements or compounds dissolved in aqueous solutions. Contaminants that can be addressed by this technology include heavy metals, nonmetallic toxic elements, radionuclides, inorganic cyanides, and inorganic corrosives.

The technology consists of a large number of cubes confined within a tubular fish net enclosure. The units may be lowered vertically into circular shafts drilled into the ground or they may be stacked in a treatment wall trench. In either mode, groundwater flows through the treatment units under the influence of gravity. The treatment units are capable of functioning for long periods of time unattended until they become saturated with the target contaminant(s). At that time they are replaced with fresh units.

Cost:
Initial costs may be high because of the required excavation of either a trench or of shafts. However, because this is a passive system requiring only periodic monitoring to ensure that the desired goals are being met and replacement of treatment units when they become saturated, the long term costs are far less than other treatment systems such as pump and treat.

ELECTRICAL SEPARATION

Description:
Electrokinetic remediation uses a series of electrodes placed in the subsurface to recover ionic contamination. Ion-permeable electrolyte casings, each containing an electrode, are placed in the subsurface and connected to a centralized electrolyte management system forming alternating rows of anodes and cathodes. The electrolyte is circulated in a closed loop between the electrode casing and the electrolyte management system which consists of an electrochemical ion exchange apparatus. When the electrodes are energized, contaminant ions in groundwater migrate under the influence of the applied potential (electromigration) to their respective electrodes (anodes for anions and cathodes for cations). The ions pass through the electrode casing walls and are taken up by the circulating electrolytes. Contaminant ions are recovered from the circulating electrolytes as they pass through the electrolyte management system.

The system treats groundwater contaminated by heavy metals (e.g., Cd, Cr, Co, Cu, Ni, Zn), toxic anions (e.g., As, CN, NO_3), toxic polar organic compounds (e.g., phenols, pesticides, herbicides), and radionuclides (e.g., Sr, Th, U).

Cost:
Initial costs may be high as a result of certain site-specific tests that must be conducted to optimize the system. However, once in place, the system is a passive treatment system that requires little hands-on attention. Groundwater needs to be monitored to ensure that the desired goals are being met, and periodically the electrochemical ion exchange apparatus must be regenerated offline. Overall, the system is highly cost effective when compared to pump and treat systems.

MONITORED NATURAL ATTENUATION

Description:
According to the U.S. EPA, the term monitored *natural attenuation* … refers to the reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remedial objectives within a time frame that is reasonable compared to that offered by more active methods. The "natural attenuation processes" that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil and groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of contaminants.

Most commonly, monitored natural attenuation is taken to mean biodegradation, i.e., the microbially mediated breakdown of organic compounds. Instead, EPA's definition above says that natural attenuation consists of a variety processes that may or may not involve the destruction of the COCs. In fact, radionuclide or metal contamination can be candidates for monitored natural attenuation if the contaminants are being sufficiently dispersed, diluted, sorbed, or transformed (e.g., Cr VI to Cr IV). The net result of each of the natural attenuation processes is that the contaminants of concern no longer pose a threat to human health or the environment.

The emphasis placed on biodegradation as a process of natural attenuation results from the fact that this naturally-occurring process results in the virtual destruction of the contaminants of concern. During biodegradation, microbes obtain their energy by either directly metabolizing an organic compound or by cometabolizing one. In either case, the compound can be ultimately broken down to a harmless chemical such as carbon dioxide.

Physical conditions in the subsurface are important to enhancing the likelihood that biodegradation will occur. For instance, some organic compounds are more readily degraded in aerobic conditions (high dissolved oxygen concentrations) whereas others are more readily degraded in anaerobic conditions (low dissolved oxygen concentrations). Often, the particular conditions that are necessary to the biodegradation of a particular compound do not exist at the site of interest. Many times, these conditions can be forced to occur at the site by injection of harmless chemicals. Once the conditions are right, naturally occurring microbes can be encouraged by the addition of a food source (biostimulation) or microbes can be added to a groundwater system if they are absent in the first place.

Groundwater monitoring is key to a monitored natural attenuation strategy. It is necessary to know if the strategy is working and, because contaminants are being left in the groundwater, it is important to ascertain whether contamination is migrating to a drinking water source or other sensitive water body.

Cost:
The cost of monitored natural attenuation is very small. However, the case for this strategy is harder to make than for most active remediation strategies. Costs include those associated with modeling, and the installation of monitoring wells and collection and analysis of groundwater samples.

BIOREMEDIATION – IN SITU GROUNDWATER by BIO-GENESIS TECHNOLOGIES

Description:
BIOPIM (Biological Process Integrated Method) is an in situ ground water treatment system which is located on the surface of the location and is an integrated part of the recirculation of ground water through the contaminated soil. Groundwater is first pumped up with vertical extraction wells. Some contaminants are biologically removed with a biological sandfilter. The BIOPIM is operated and compressed air is added in a downflow direction. The effluent is enriched with oxygen, microorganisms, and nutrients which are infiltrated into the soil. Contaminated groundwater is purified in the BIOPIM and enriched with oxygen, nutrients, and microorganisms before it is reinjected into the soil.

Contaminants that can be treated are organic compounds that are biologically aerobic degradable such as BTEX, TPH, and phenol. Metals and organic contaminants which are not degradable by aerobic biodegradation are not removed.

Cost:
The remediation will cost between 0.1 and 2.0 Ductch Guilders per cubic meter of groundwater depending on teh flow and the load of contaminants.

HYDRAULIC AND PNEUMATIC FRACTURING

Hydraulic and pneumatic fracturing are two technologies that induce fracturing in the subsurface to enhance the remediation of contaminants both above and beneath the potentiometric surface. These technologies are particularly useful in contaminated sites with low-permeability soil and geologic media, such as clays, shales, and tight sandstones where remediation, without some sort of permeability enhancement, is difficult. These techniques enhance the fracture network to increase soil permeability to liquids and vapors to accelerate contaminant removal. Fracturing can be combined with other technologies to provide an effective remediation system.

Hydraulic fracturing involves the injection of high-pressure water into the borehole to cut a notch; slurry of water, sand and thick gel is pumped at high pressure into the borehole to propagate the fracture from the initial notch. The gel then biodegrades which leaves a highly permeable sand-filled lens which can range up to 60 feet in diameter.

Pneumatic fracturing is most applicable for unconsolidated sediments or bedrock. This technology involves the injection of highly pressurized air intc consolidated sediments to extend existing fractures and create a secondary fracture network. A directional nozzle can be used to control the direction of fracture propagation.

Fractures are typically created in a horizontal or subhorizontal plan which are held open naturally or with a gel which is mentioned above. The direction of fracture propagation is controlled by the amount of stress in the subsurface.

DIRECTIONAL WELLS

Directional drilling techniques are used to position wells horizontally, or at an angle, to reach contaminants that are not accessible by vertical wells. Hydraulically activated thrust equipment, which can exert more than 40 tons is used to push the directional boring heads into the subsurface with proper positioning of the face of the boring head. Slow rotation of the boring head cuts and compacts the geologic material into the borehole wall. The machinery can initiate a borehole, steer down to a desired horizontal depth, continue at that depth, and steer back to the surface at a location downgradient. Directional drilling is limited to depths of less than 50 feet.

Horizontal wells contact a larger area of contaminated media and may more effectively transmit additives associated with remedial activities due to their long horizontal screens contacting a larger area of contaminated media. The configuration of these wells is consistent with natural conditions; groundwater transmissivity is generally greater in horizontal directions than vertical. This may allow for a more efficient recovery of groundwater and/or vapors. Directionally drilled horizontal wells can be installed in areas of subsurface obstructions such as vertical wells and utility lines and beneath surface obstructions such as buildings lagoons, wetlands, etc.

Directional wells are applicable to a large range of contaminant groups and can be used to enhance other in-situ or in-well technologies.

Cost:
The installation of a horizontal well is costly and can range from $20 to $75 per foot for hydraulic bi-directional thrust drilling.

DUAL PHASE EXTRACTION

Dual phase extraction (DPE) is also known as multi-phase extraction, vacuum-enhanced extraction, or bioslurping. DPE uses a vacuum system to remove various combinations of contaminated ground water, separate-phase petroleum product, and hydrocarbon vapor from the subsurface. Extractable liquids and vapor are extracted, treated and collected for disposal, or re-injected to the subsurface. This technology is suited for low permeability or heterogeneous formations. The vacuum extraction well includes a screened section in the zone of contaminated soils and ground water; contaminants are removed from both above or below the potentiometric surface. The system lowers the potentiometric surface around the wells, exposing more of the formation; contaminants exposed are then accessible to vapor extraction. Once extracted, the vapors or liquid-phase organics and ground water are separated and treated. VOCs and fuels are DPEs target contaminants.

DPE is generally combined with another remediation technique such as bioremediation or bioventing to shorten the cleanup time at a site.

Cost:
There are a large number of variances involved with the Duel phase extraction that makes it difficult to establish a general cost. The key cost factors for the recovery of the product include waste disposal, potential for sale of recovered product for recycling, on-site equipment rental, installation of permanent equipment, and engineering and testing costs.

6.0 Site Management Alternatives

Because contamination of ground water presents difficult issues from technical, regulatory, and policy perspectives, it is important to recognize that a mix of tools should be considered in minimizing the programmatic vulnerability to negative impacts from ground-water issues.

6.1 Technical Approaches

6.1.1 The Technical Planning Process

It is fundamentally important to acknowledge that the site and regional hydro-geochemical conditions be understood sufficiently to make informed, defensible decisions. This means having sufficient information to predict the likelihood that a potential remedial strategy will result in a favorable outcome for the USACE.

A useful management tool for assuring adequacy of information has been developed by the USACE. It is known as the technical planning process (TPP). This can be used effectively to bring together FUSRAP site managers, technical experts, regulators, and other decision makers to systematically evaluate the type of information that will be required to reach a successful site closeout.

Typically, the technical planning process takes two to three days to complete. But, it results in a clear path for understanding how ground water will be addressed. "In many cases, TPPs established the standards of proof and level of understanding that must be met to assure that the site closeout is successful for all project stakeholders. The TPP can also assist in identifying alternatives that should be considered if remedial goals are not met." MCLs are not used in all cases because the EPA is not the enforcer; the NYSDEC is used at all of the Buffalo sites. However, the MCLs are used as default.

6.1.2 Risk-based Remedies

It is clear that a large majority of the important water resources impacted by FUSRAP-related contaminants are only mildly impaired. While MCLs are an easy standard to use to decide whether significant impacts may have occurred to a resource, they should not be used carte blanche to establish the clean up standards. Most of the FUSRAP sites are in industrial areas where water quality standards should be established by realistic anticipated use and the risk associated with that use. It is particularly important to establish solid background values for the important water resources, which has not been adequately accomplished to date on FUSRAP.

6.1.3 Compare Remedies

It is likely that previous cleanups have established useful precedents for ground water remedial actions in similar settings and regulatory environments. With a small amount of research, legal and regulatory precedents may be identified that allow cleanups to proceed at levels less stringent than the generic MCLs.

6.1.4 Develop Decision Structures

Every action has a probability associated with the likelihood that the outcome will be successful. Combining the probabilities with the costs of the actions allows the approach to a remedy to be optimized for cost versus the probability for successful outcome of the project. It also allows a clear understanding of the cost impacts associated with failure to achieve a successful outcome and the costs associated with alternative approaches. This type of information provides the project manager with a powerful tool for cost effective decision making.

6.1.5 Programmatic Direction

It is essential that programmatic direction be provided on ground water management and remedial strategies. Technical and policy consistency can only create better, more cost effective remedies at the site level. The technical planning process would be a very effective way of providing programmatic consistency while allowing sites a maximum level of autonomy.

7.0 Quantification of Costs

An estimate of the costs associated with necessary characterization related to ground water on each site is located in this section. Table 7.1 lists current monitoring and characterization and also recommend general characterization that is needed. This proposed characterization is then broken down into estimated costs for each site.

Table 7.1 Current and Proposed Characterization

Site	**Background**		**Monitoring/Well Redevelopment**	**Characterization Needed**		**Proposal for/Characterization in Progress**
	Background needed	Monitoring Wells/Sampling Needed		***Description***	Monitoring Wells/Boreholes	
St. Louis Sites						
SLDS 45 acres & VPs	Needed	SAIC has proposed additional background wells	Well development in progress Sampling -quarterly for cadmium, arsenic, and radionuclides			-Background characterization
SLAPS 22 acres / HISS 8 acres & VPs	Needed	SAIC has proposed additional background wells	Well development in progress Sampling -full suite of unfiltered and filtered samples at all sites if turbidity if greater than 50 NTU -quarterly			-Characterization of the Post-Maquoketa Aquifer: background, yield, and hydraulic conductivity -Background characterization
New York District						
Maywood 30 acres	Needed	4 Wells -quarterly sampling -full analysis -2 years at least -15 feet in depth ~ $ 79,000	Bechtel is in charge of groundwater monitoring, since the mid 1980s: Quarterly: VOCs and SVOCs are sampled from wells of the most concern Semi-Annually: SVOCs and VOCs are tested in some wells that exceed MCL guidance Annually: A full chemical suite is analyzed in all wells			-Extent of VOC and metal contamination downgradient of site -Extent of PCE plume downgradient -Groundwater flow groundwater entry into westerly brook, interaction between groundwater systems

Middlesex 9.6 acres	Needed	2 Wells -quarterly sampling -full analysis -2 years at least -1 well 3 feet in depth -1 well 20 feet in depth ~ $ 39,000	Wells are sampled annually for pH, Eh, dissolved oxygen, chemical, metals, and radionuclide parameters	-Shallow and deep ground-water system	-1-3 well pairs -Full suite analysis for the first 2.5 years until COCs are determined -20 feet deep	-Has recommended going to quarterly monitoring -A RI is in progress
Wayne 6.5 acres	Regional background needed Site background is sufficient, there is no migration off-site	2 Wells -quarterly sampling -30 feet deep -at least 2 years of sampling -full analysis ~$ 42,000	Bechtel is in charge of groundwater monitoring:	Characterization is complete, excavation has begun and groundwater monitoring will continue for 5 years to ensure that there are no unacceptable levels of contamination		
Buffalo District						
Luckey	In the process					-A RI is in the process of being formed along with decisions about data gaps
Painesville 38 acres	Needed	4 Wells -quarterly sampling -35 feet deep -at least 2 years of sampling -full analysis ~$ 83,000		-Estimate of potential for migration of contaminants through the silty clay layer to the regional water surface	3 wells, 35 feet deep -quarterly sampling -sample chemical, radiological, SVOC, VOC -Full suite analysis for the first 2.5 years until COCs are determined ~$ 76,000	-An EE/CA is being finalized
Tonawanda: Ashland 1 10.8 acres, Ashland 2 115 acres Linde 135 acres, Seaway 100 acres	Needed	6 Wells -quarterly sampling -15 feet deep -at least 2 years -full analysis note: the Camillus *Shale is confined by 70-90 feet of glacial overburden ~$ 117,000				

NFSS	Needed	-We do not have sufficient information to make assumptions				-A RI is currently underway, with plans to install several additional wells and determine seasonal ground water elevation fluctuations
New England District						
Combustion Engineering 600 acres	Needed	6 Wells -quarterly sampling -35 feet deep -at least 2 years -full analysis ~$ 125,000		-Characterization of metals, Eh, pH, dissolved oxygen, cations/anions	-Sample wells for Eh, pH, dissolved oxygen, and cations/anions -assume 15 wells -quarterly -Full suite analysis for the first 2.5 years until COCs are determined ~$ 308,000	
Shpack 8 acres	Needed	2 Wells -quarterly sampling -50 feet deep -at least 2 years -full analysis ~$ 44,000		-Groundwater flow characterization -Extent of contamination -Characterization of PCBs, organics, and inorganics within the radiological contamination	Additional wells -4 wells 30 feet in depth -3 wells 50 feet in depth -Full suite analysis for the first 2.5 years until COCs are determined ~$ 173,000 Sampling -quarterly -assume 7 existing wells and 7 proposed wells -Full suite analysis for the first 2.5 years until COCs are determined - analyze PCBs, organics, inorganics ~$ 320,000	
CISS 11.2 acres	Sufficient		Bechtel is in charge of groundwater sampling: -radionuclides, metals, VOCs, SVOCs, pH, Eh	-Chemical constituents need to be characterized	Sampling -assume 15 exstg wells -Full suite analysis for the first 2.5 years until COCs are determined ~$ 308,000	-Direction of groundwater flow onto and from the site

W.R. Grace 4 acres	Needed	2 Wells -quarterly sampling -50 feet deep -at least 2 years -full analysis ~$ 44,000	No wells have been installed at this site	-Groundwater characterization -Subsurface characterization (50 feet above the Chesepeake Bay)	9 Wells -4 wells 25 feet in depth -5 wells 50 feet in depth -quarterly sampling -Full suite analysis for the first 2.5 years until COCs are determined sampling ~$ 221,000	
Philadelphia District						
DuPont	Needed	4 Wells -quarterly sampling -20-40 feet deep -quarterly sampling -at least 2 years -full analysis ~$ 82,000	There is no current sampling at the site	-Site hydrogeology and geology -Radiological contamination boundaries -Nature and extent of hazardous contaminants -Characterization of metals, organics, pH, dissolved oxygen, cations/anions	7 Wells -20-40 feet deep -quarterly sampling -full analysis -Full suite analysis for the first 2.5 years until COCs are determined ~$ 170,000	Note: parameters are very broad because no hydrogeologic information can be found.

Note: The above assumptions are based on limited information and are subject to change. This table should solely be used as a general estimate of characterization needed

St. Louis Sites

- St. Louis Downtown Site (SLDS) and its associated vicinity properties (VPs)
- North County Sites: Including the St. Louis Airport Site (SLAPS), Hazelwood Interim Storage Site (HISS), and Vicinity Properties (VPs)

New York District

- Wayne Interim Storage Site (WISS)
- Maywood Interim Storage Site (MISS)
- Middlesex Sampling Plant (MSP)

Buffalo

- Tonawanda Sites
  - Ashland 1 and 2
  - Linde
  - Seaway Industrial Park
  - Niagara Falls Storage Site (NFSS)
- Ohio
  - Luckey
  - Painesville

Baltimore

- Colonie Interim Storage Site (CISS)
- Shpack Landfill
- W.R. Grace

New England

- Combustion Engineering (CE)

Philadelphia

- DuPont Chamber Works

8.0 Recommendations

- Research development of consistent programmatic policy for addressing issues related to groundwater in the regulatory and technical climate of the FUSRAP sites.

- It is recommended that in future revisions of this document program policy will be added for supplying alternate drinking water sources, the desirability of passive vs. Active types of remediation, etc.

- Survey potential users of aquifers downgradient from the aquifers affected by FURAP.

- Research into the differencing groundwater cleanup criteria currently held by the EPA vs. the NRC.

- A study into DOE's UMTRA groundwater program study identifying the lessons learned.

- There is widely differing groundwater cleanup criteria currently held by EPA vs. NRC; for most of the FUSRAP sites, we should be concentrating on risk-based criteria with realistic pathway analysis. However, the differences between the EPA and NRC should be further researched and discussed.

- It was beyond the scope of this document to delve into the quality of well development across each FUSRAP site. However, it is important that wells be assessed for their integrity, development, and purging history by using available development logs and recent sampling logs including parameter data. Redevelopment is necessary when there is lack of documentation regarding well installation methods, including well development, or if the wells have been idle for extended lengths of time. It is recommended that well redevelopment be carried out at all applicable sites. The St. Louis site and possibly other sites have already begun this process. Consistent and detailed logging of well redevelopment is necessary to create a baseline for the collection of future ground water sampling.

- Standardization of sampling methods should be implemented throughout all of the sites. Some sites have begun establishing Sampling and Analysis Plans that are standard throughout the individual site. These plans should be implemented throughout all of the FUSRAP sites. For instance, low-flow sampling for metals, radionuclides, and volatiles should be included in this standardizaiton.

- Standardization of geochemical data collection should also be implemented. Samples such as Eh, pH, dissolved oxygen, cations/anions, etc. should be incorporated into the Sampling and Analysis Plan to support evaluation of a full range of remedial measures.

- A conceptual ground water model should be constructed or updated at each FUSRAP site within its regional setting.
- Investigations into how each site addresses PRP issues should be carried out.

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ACRONYMS

AEC	Atomic Energy Commission
BBC	Brush Beryllium Capacity
BNAE	Base/Neutral and Acid Extractable
BNI	Bechtel National, Inc.
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
COC	Contaminants of Concern
CPM	Counts Per Minute
DCG	
DMC	Diamond Magnesium Company
DOE	Department of Energy
DCG	Derived Concentration Guide
DPC	Defense Plant Corporation
EM	Electromagnetic
EP-TOX	Extraction Procedure-Toxicity
EPA	Environmental Protection Agency
FFA	Federal Facilities Agreement
FIDLER	Field Instrumentation for Detecting Low-Energy Radiation
FUSRAP	Formerly Utilized Sites Remedial Action Program
GSA	General Services Administration
GWS	Ground Water Sampling?
HEU	Highly Enriched Uranium
HISS	Hazelwood Interim Storage Site
LMAS	Multiunit Aquifer System
LOSA	
MCL	Maximum Contaminant Level
MED	Manhattan Engineer District
MISS	Maywood Interim Storage Site
MSP	Middlesex Sampling Plant
MTBE	Methyl-T-butylcther
NEPA	National Environmental Policy Act
NFSS	Niagara Falls Storage Site
NJGWQS	New Jersey Groundwater Quality Standards
NL	National Land
NPL	National Priorities List
ORNL	
PCB	Polychlorinated Biphenyl
PCOC	Potential Contaminant of Concern
ppb	parts per billion
PRP	Potentially Responsible Parties
RBCs	
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation

SAP	Sampling and Analysis Plan
SDWA	Safe Drinking Water Act
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
SMCL	Secondary Maximum Contaminant Level
SOR	Sum of Ratios
SRC	Site-Related Contaminants
SSL	Soil Screening Level
SVOC	Semi-Volatile Organic Compound
TCE	Trichloroethene
TCLP	
TPP	Technical Project Planning
USACE	United States Army Corp of Engineers
VOC	Volatile Organic Compound
VP	Vicinity Property
WISS	Wayne Interim Storage Site

National Primary Drinking Water Regulations

Referenced from: EPA Office of Water Current Drinking Water Standards
http://www.epa.gov/OGWDW/wot/appa.html

Note: The MCLs are provided only as a point of reference.

Contaminants	MCLG[1] (mg/L)[4]	MCL[2] or TT[3] (mg/L)[4]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Inorganic Chemicals				
Antimony	0.006	0.006	Increase in blood cholesterol; decrease in blood glucose	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder
Arsenic	none[5]	0.05	Skin damage; circulatory system problems; increased risk of cancer	Discharge from semiconductor manufacturing; petroleum refining; wood preservatives; animal feed additives; herbicides; erosion of natural deposits
Asbestos (fiber 10 micrometers)	7 million fibers per Liter	7 MFL	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits
Barium	2	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits
Beryllium	0.004	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries
Cadmium	0.005	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints
Chromium (total)	0.1	0.1	Some people who use water containing chromium well in excess of the MCL over many years could experience allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits
Copper	1.3	Action Level=1.3; TT[6]	Short term exposure: Gastrointestinal distress. Long term exposure: Liver or kidney damage. Those with Wilson's Disease should consult their personal doctor if their water systems exceed the copper action level.	Corrosion of household plumbing systems; erosion of natural deposits; leaching from wood preservatives
Cyanide (as free cyanide)	0.2	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories
Fluoride	4.0	4.0	Bone disease (pain and tenderness of the bones); Children may get mottled teeth.	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories
Lead	zero	Action Level=0.015; TT[6]	Infants and children: Delays in physical or mental development. Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits
Inorganic Mercury	0.002	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and cropland

Nitrate (measured as Nitrogen)	10	10	"Blue baby syndrome" in infants under six months - life threatening without immediate medical attention. Symptoms: Infant looks blue and has shortness of breath.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
Nitrite (measured as Nitrogen)	1	1	"Blue baby syndrome" in infants under six months - life threatening without immediate medical attention. Symptoms: Infant looks blue and has shortness of breath.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
Selenium	0.05	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines
Thallium	0.0005	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and pharmaceutical companies

Organic Chemicals	**MCLG[1] (mg/L)[4]**	**MCL[2] or TT[3] (mg/L)[4]**	**Potential Health Effects from Ingestion of Water**	**Sources of Contaminant in Drinking Water**
Acrylamide	zero	TT[7]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/wastewater treatment
Alachlor	zero	0.002	Eye, liver, kidney or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops
Atrazine	0.003	0.003	Cardiovascular system problems; reproductive difficulties	Runoff from herbicide used on row crops
Benzene	zero	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills
Benzo(a)pyrene	zero	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines
Carbofuran	0.04	0.04	Problems with blood or nervous system; reproductive difficulties.	Leaching of soil fumigant used on rice and alfalfa
Carbon tetrachloride	zero	.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities
Chlordane	zero	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide
Chlorobenzene	0.1	0.1	Liver or kidney problems	Discharger from chemical and agricultural chemical factories
2,4-D	0.07	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops
Dalapon	0.2	0.2	Minor kidney changes	Runoff from herbicide used on rights of way
1,2-Dibromo-3-chloropropane (DBCP)	zero	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards
o-Dichlorobenzene	0.6	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories
p-Dichlorobenzene	0.075	0.075	Anemia; liver, kidney or spleen damage; changes in blood	Discharge from industrial chemical factories
1,2-Dichloroethane	zero	0.005	Increased risk of cancer	Discharge from industrial chemical factories

1-1-Dichloroethylene	0.007	0.007	Liver problems	Discharge from industrial chemical factories
cis-1, 2-Dichloroethylene	0.07	0.07	Liver problems	Discharge from industrial chemical factories
trans-1,2-Dichloroethylene	0.1	0.1	Liver problems	Discharge from industrial chemical factories
Dichloromethane	zero	0.005	Liver problems; increased risk of cancer	Discharge from pharmaceutical and chemical factories
1-2-Dichloropropane	zero	0.005	Increased risk of cancer	Discharge from industrial chemical factories
Di(2-ethylhexyl)adipate	0.4	0.4	General toxic effects or reproductive difficulties	Leaching from PVC plumbing systems; discharge from chemical factories
Di(2-ethylhexyl)phthalate	zero	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories
Dinoseb	0.007	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables
Dioxin (2,3,7,8-TCDD)	zero	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories
Diquat	0.02	0.02	Cataracts	Runoff from herbicide use
Endothall	0.1	0.1	Stomach and intestinal problems	Runoff from herbicide use
Endrin	0.002	0.002	Nervous system effects	Residue of banned insecticide
Epichlorohydrin	zero	TT[1]	Stomach problems; reproductive difficulties; increased risk of cancer	Discharge from industrial chemical factories; added to water during treatment process
Ethylbenzene	0.7	0.7	Liver or kidney problems	Discharge from petroleum refineries
Ethelyne dibromide	zero	0.00005	Stomach problems; reproductive difficulties; increased risk of cancer	Discharge from petroleum refineries
Glyphosate	0.7	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use
Heptachlor	zero	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide
Heptachlor epoxide	zero	0.0002	Liver damage; increased risk of cancer	Breakdown of hepatachlor
Hexachlorobenzene	zero	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories
Hexachlorocyclopentadiene	0.05	0.05	Kidney or stomach problems	Discharge from chemical factories
Lindane	0.0002	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on catttle, lumber, gardens
Methoxychlor	0.04	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, livestock
Oxamyl (Vydate)	0.2	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes
Polychlorinated biphenyls (PCBs)	zero	0.0005	Skin changes; thymus gland problems; immune difficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfils; discharge of waste chemicals
Pentachlorophenol	zero	0.001	Liver or kidney problems; increased risk of cancer	Discharge from wood preserving factories
Picloram	0.5	0.5	Liver problems	Herbicide runoff
Simazine	0.004	0.004	Problems with blood	Herbicide runoff
Styrene	0.1	0.1	Liver, kidney, and circulatory problems	Discharge from rubber and plastic factories; leaching from landfills

Tetrachloroethylene	zero	0.005	Liver problems; increased risk of cancer	Leaching from PVC pipes; discharge from factories and dry cleaners
Toluene	1	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories
Total Trihalomethanes (TTHMs)	none[5]	0.10	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection
Toxaphene	zero	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle
2,4,5-TP (Silvex)	0.05	0.05	Liver problems	Residue of banned herbicide
1,2,4-Trichlorobenzene	0.07	0.07	Changes in adrenal glands	Discharge from textile finishing factories
1,1,1-Trichloroethane	0.20	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories
1,1,2-Trichloroethane	0.003	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories
Trichloroethylene	zero	0.005	Liver problems; increased risk of cancer	Discharge from petroleum refineries
Vinyl chloride	zero	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories
Xylenes (total)	10	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories
Radionuclides	**MCLG[1] (mg/L)[4]**	**MCL[2] or TT[3] (mg/L)[4]**	**Potential Health Effects from Ingestion of Water**	**Sources of Contaminant in Drinking Water**
Beta particles and photon emitters	none[5]	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits
Gross alpha particle activity	none[5]	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits
Radium 226 and Radium 228 (combined)	none[5]	5 pCi/L	Increased risk of cancer	Erosion of natural deposits
Microorganisms	**MCLG[1] (mg/L)[4]**	**MCL[2] or TT[3] (mg/L)[4]**	**Potential Health Effects from Ingestion of Water**	**Sources of Contaminant in Drinking Water**
Giardia lamblia	zero	TT[8]	Giardiasis, a gastroenteric disease	Human and animal fecal waste
Heterotrophic plate count	N/A	TT[8]	HPC has no health effects, but can indicate how effective treatment is at controlling microorganisms.	n/a
Legionella	zero	TT[8]	Legionnaire's Disease, commonly known as pneumonia	Found naturally in water; multiplies in heating systems
Total Coliforms (including fecal coliform and *E. Coli*)	zero	5.0%[9]	Used as an indicator that other potentially harmful bacteria may be present[10]	Human and animal fecal waste
Turbidity	N/A	TT[8]	Turbidity has no health effects but can interfere with disinfection and provide a medium for microbial growth. It may indicate the presence of microbes.	Soil runoff
Viruses (enteric)	zero	TT[8]	Gastroenteric disease	Human and animal fecal waste

Table 1

National Secondary Drinking Water Regulations

National Secondary Drinking Water Regulations (NSDWRs or secondary standards) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards. See Table 2.

Contaminant	Secondary Standard
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

Table 2

Notes

[1] Maximum Contaminant Level Goal (MCLG) - The maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health effect of persons would occur, and which allows for an adequate margin of safety. MCLGs are non-enforceable public health goals.

[2] Maximum Contaminant Level (MCL) - The maximum permissible level of a contaminant in water which is delivered to any user of a public water system. MCLs are enforceable standards. The margins of safety in MCLGs ensure that exceeding the MCL slightly does not pose significant risk to public health.

[3] Treatment Technique - An enforceable procedure or level of technical performance which public water systems must follow to ensure control of a contaminant.

[4] Units are in milligrams per Liter (mg/L) unless otherwise noted.

[5] MCLGs were not established before the 1986 Amendments to the Safe Drinking Water Act. Therefore, there is no MCLG for this contaminant.

[6] Lead and copper are regulated in a Treatment Technique which requires systems to take tap water samples at sites with lead pipes or copper pipes that have lead solder and/or are served by lead service lines. The action level, which triggers water systems into taking treatment steps if exceeded in more than 10% of tap water samples, for copper is 1.3 mg/L, and for lead is 0.015mg/L.

[7] Each water system must certify, in writing, to the state (using third-party or manufacturer's certification) that when acrylamide and epichlorohydrin are used in drinking water systems, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows:

- **Acrylamide** = 0.05% dosed at 1 mg/L (or equivalent)
- **Epichlorohydrin** = 0.01% dosed at 20 mg/L (or equivalent)

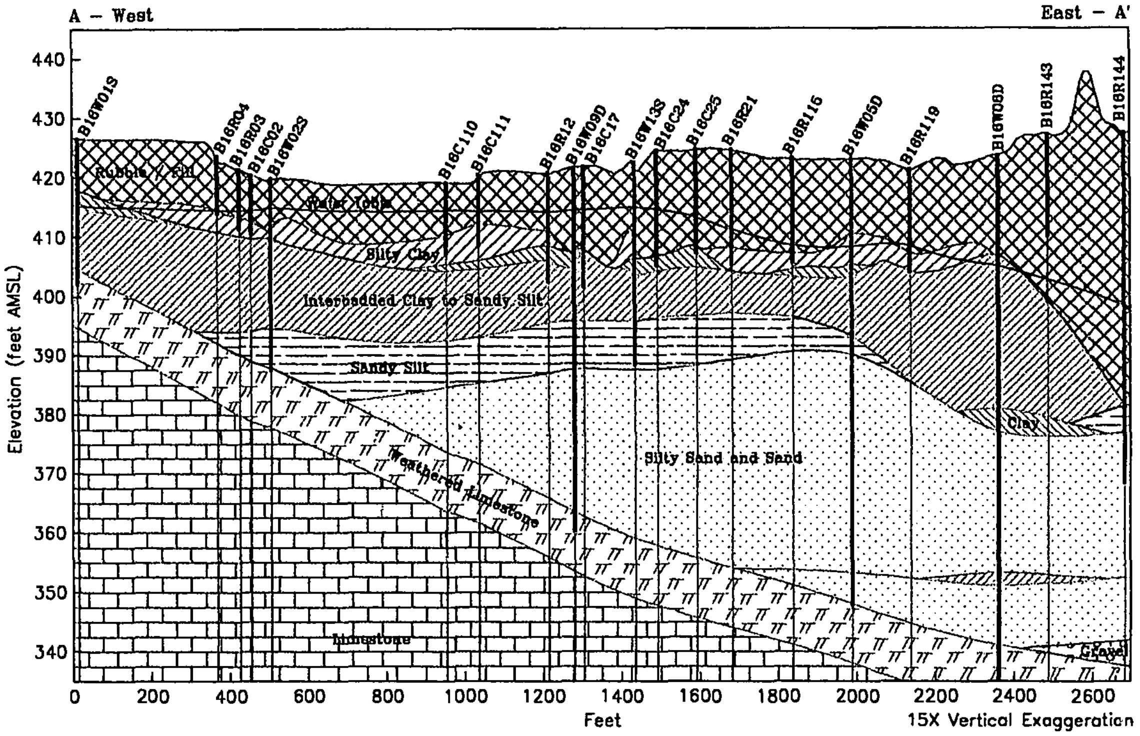
[8] The Surface Water Treatment Rule requires systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water to meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

- ***Giardia lamblia***: 99.9% killed/inactivated
  Viruses: 99.99% killed/inactivated
- ***Legionella***: No limit, but EPA believes that if *Giardia* and viruses are inactivated, *Legionella* will also be controlled.
- **Turbidity**: At no time can turbidity (cloudiness of water) go above 5 nephelolometric turbidity units (NTU); systems that filter must ensure that the turbidity go no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples for any two consecutive months.
- **HPC**: NO more than 500 bacterial colonies per milliliter.

[9] No more than 5.0% samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive). Every sample that has total coliforms must be analyzed for fecal coliforms. There cannot be any fecal coliforms.

[10] Fecal coliform and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human animal wastes. Microbes in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms.

Figure 2.1 National Location Map

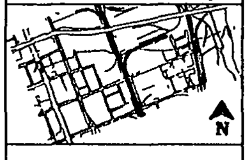


SLDS Figure 3.1

Geologic Cross Section A – A' at SLDS

Geologic data used in the cross section collected prior to 1998.

Cross Section Location Map



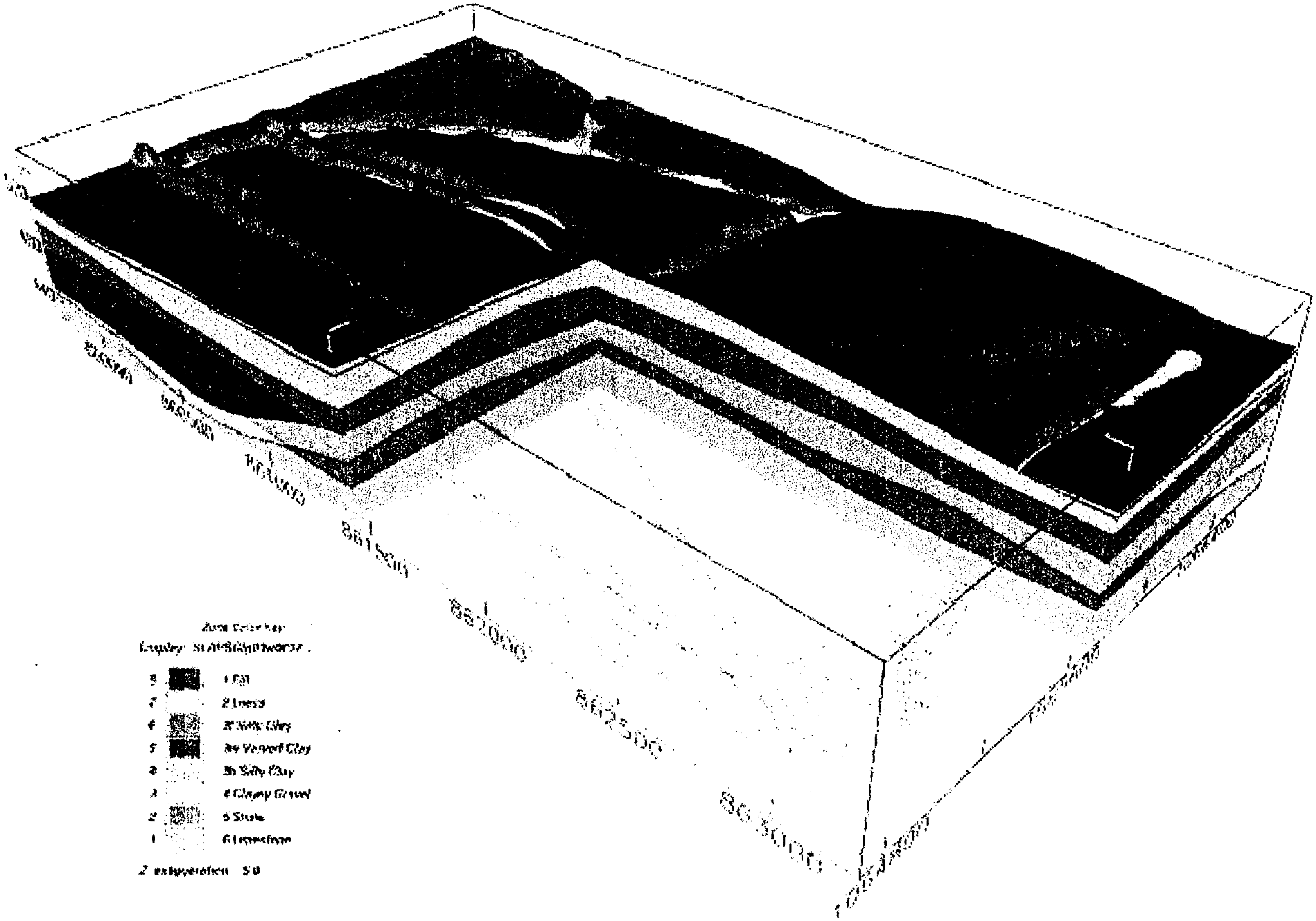
FUSRAP

St. Louis Downtown Site
St. Louis, Missouri

Drawn By: R. Smith

Rev. No. / Date: 0 / 24 Mar 99

File: SLDSGlg01XSectA.sho



SLAPS/HISS Figure 3.1

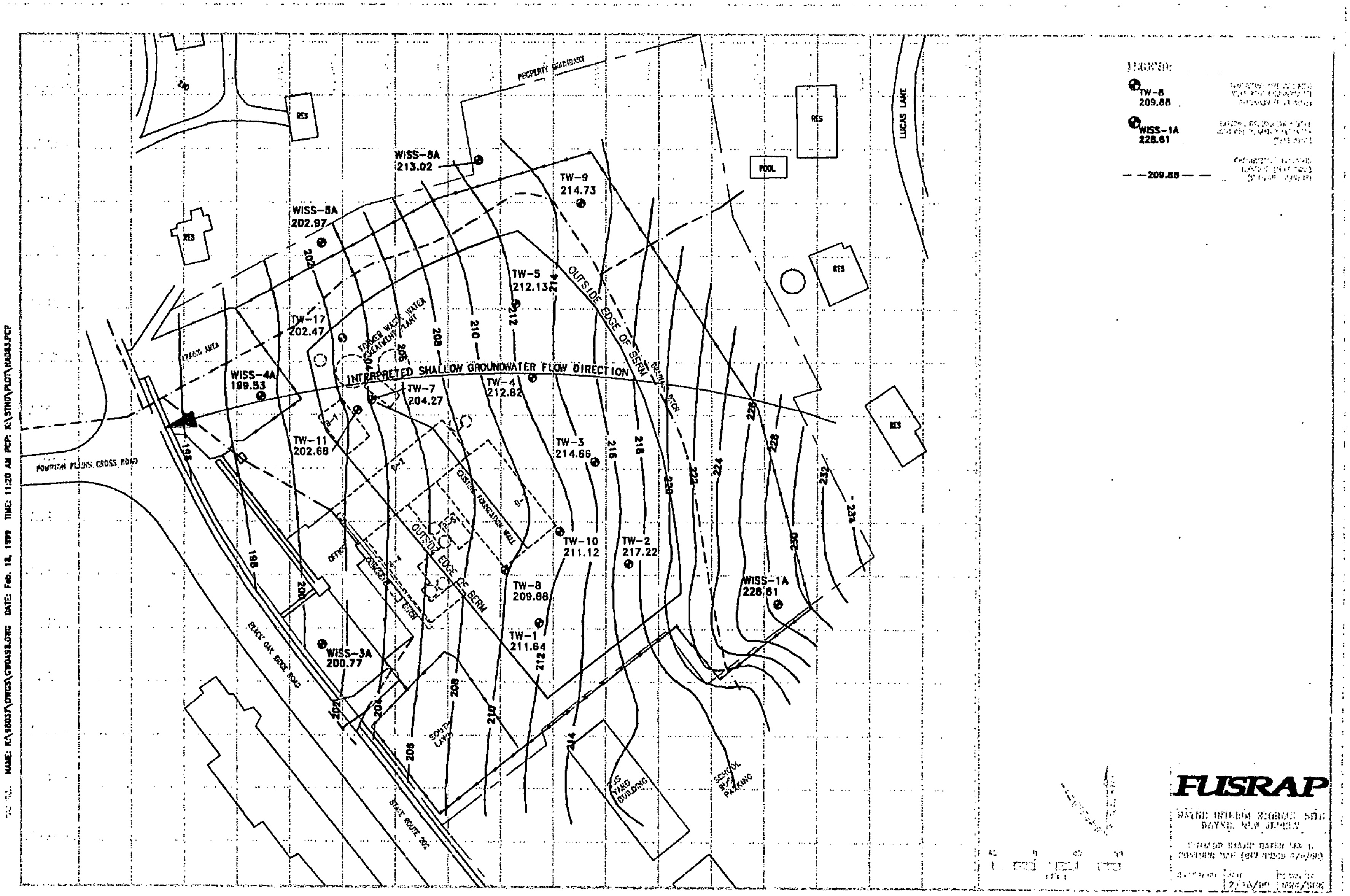


Figure 2-12. Shallow Static Water Level Contour Map (measured 4/9/98)

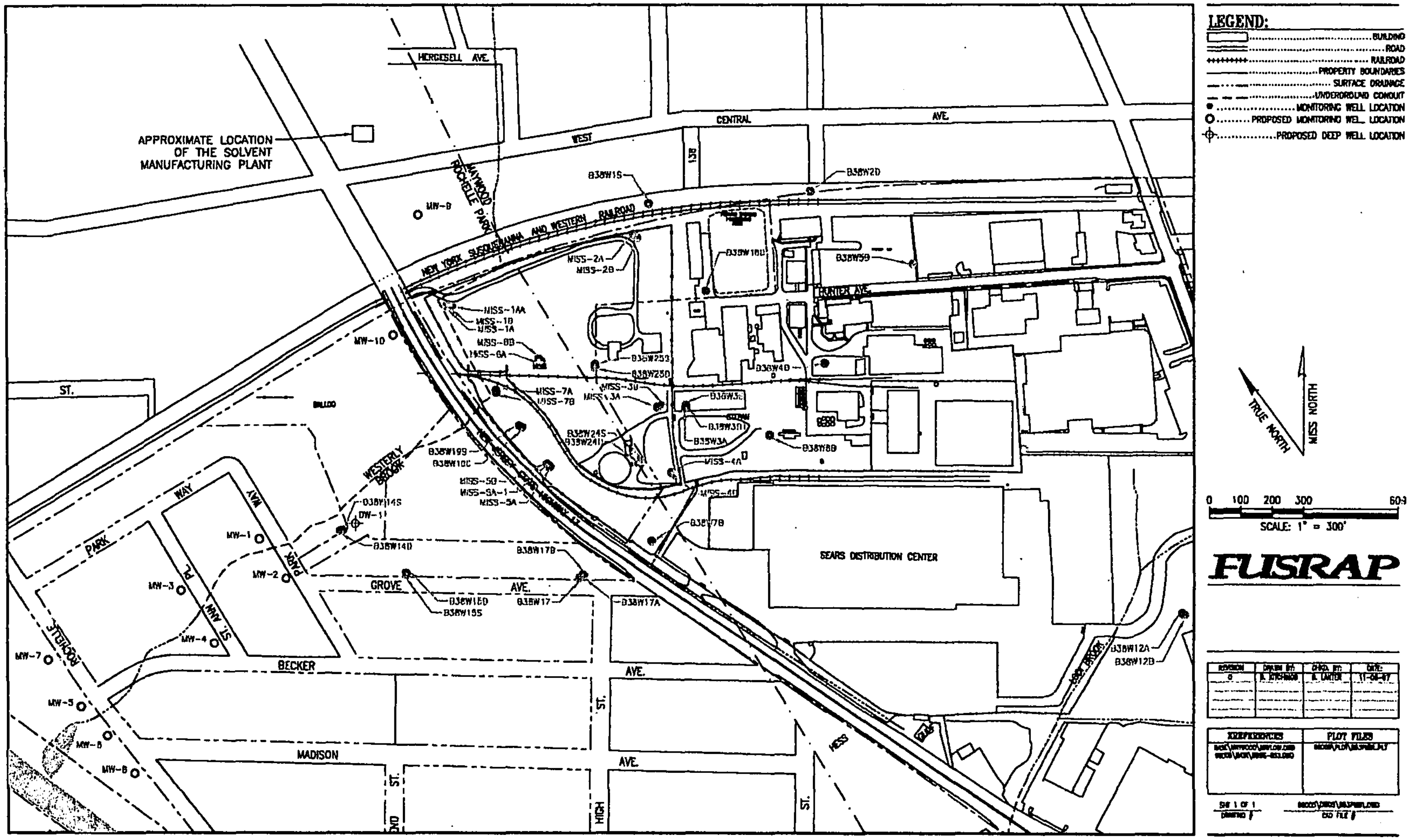
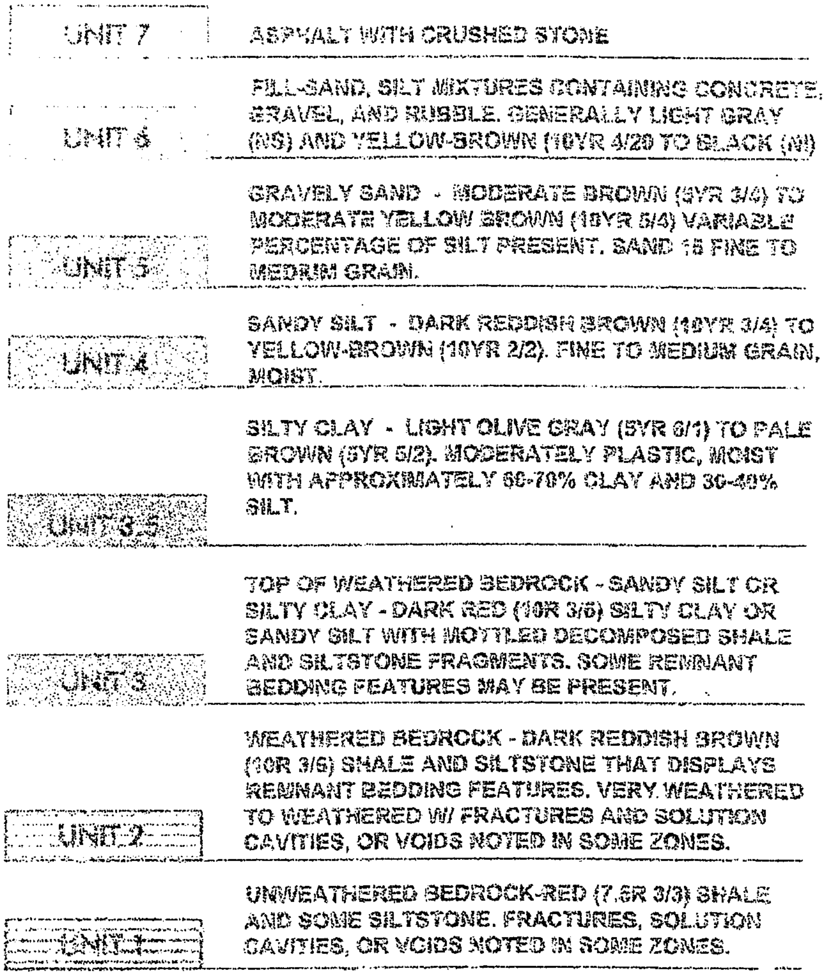


Fig. B-2 Proposed Monitoring Well Locations

MSP STRATIGRAPHIC COLUMN



UNIT 7	ASPHALT WITH CRUSHED STONE
UNIT 6	FILL-SAND, SILT MIXTURES CONTAINING CONCRETE, GRAVEL, AND RUBBLE. GENERALLY LIGHT GRAY (N8) AND YELLOW-BROWN (10YR 4/20 TO BLACK (N1)
UNIT 5	GRAVELY SAND - MODERATE BROWN (5YR 3/4) TO MODERATE YELLOW BROWN (10YR 5/4) VARIABLE PERCENTAGE OF SILT PRESENT. SAND IS FINE TO MEDIUM GRAIN.
UNIT 4	SANDY SILT - DARK REDDISH BROWN (10YR 3/4) TO YELLOW-BROWN (10YR 2/2). FINE TO MEDIUM GRAIN, MOIST.
UNIT 3.5	SILTY CLAY - LIGHT OLIVE GRAY (5YR 6/1) TO PALE BROWN (5YR 5/2). MODERATELY PLASTIC, MOIST WITH APPROXIMATELY 60-70% CLAY AND 30-40% SILT.
UNIT 3	TOP OF WEATHERED BEDROCK - SANDY SILT OR SILTY CLAY - DARK RED (10R 3/6) SILTY CLAY OR SANDY SILT WITH MOTTLED DECOMPOSED SHALE AND SILTSTONE FRAGMENTS. SOME REMNANT BEDDING FEATURES MAY BE PRESENT.
UNIT 2	WEATHERED BEDROCK - DARK REDDISH BROWN (10R 3/6) SHALE AND SILTSTONE THAT DISPLAYS REMNANT BEDDING FEATURES. VERY WEATHERED TO WEATHERED W/ FRACTURES AND SOLUTION CAVITIES, OR VOIDS NOTED IN SOME ZONES.
UNIT 1	UNWEATHERED BEDROCK-RED (7.5R 3/3) SHALE AND SOME SILTSTONE. FRACTURES, SOLUTION CAVITIES, OR VOIDS NOTED IN SOME ZONES.

SOURCE: WESTON 1989, SAIC 1995, BNI 1990b, BNI 1997b

FUSRAP

MIDDLESEX SAMPLING PLANT
HYDROGEOLOGIC ASSESSMENT
MIDDLESEX, NEW JERSEY

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P. HOLM	REV. 2/ 12/05/97	[illegible]/DWGS/[illegible].DWG

MSP Figure 3.1 MSP Stratigraphic Column

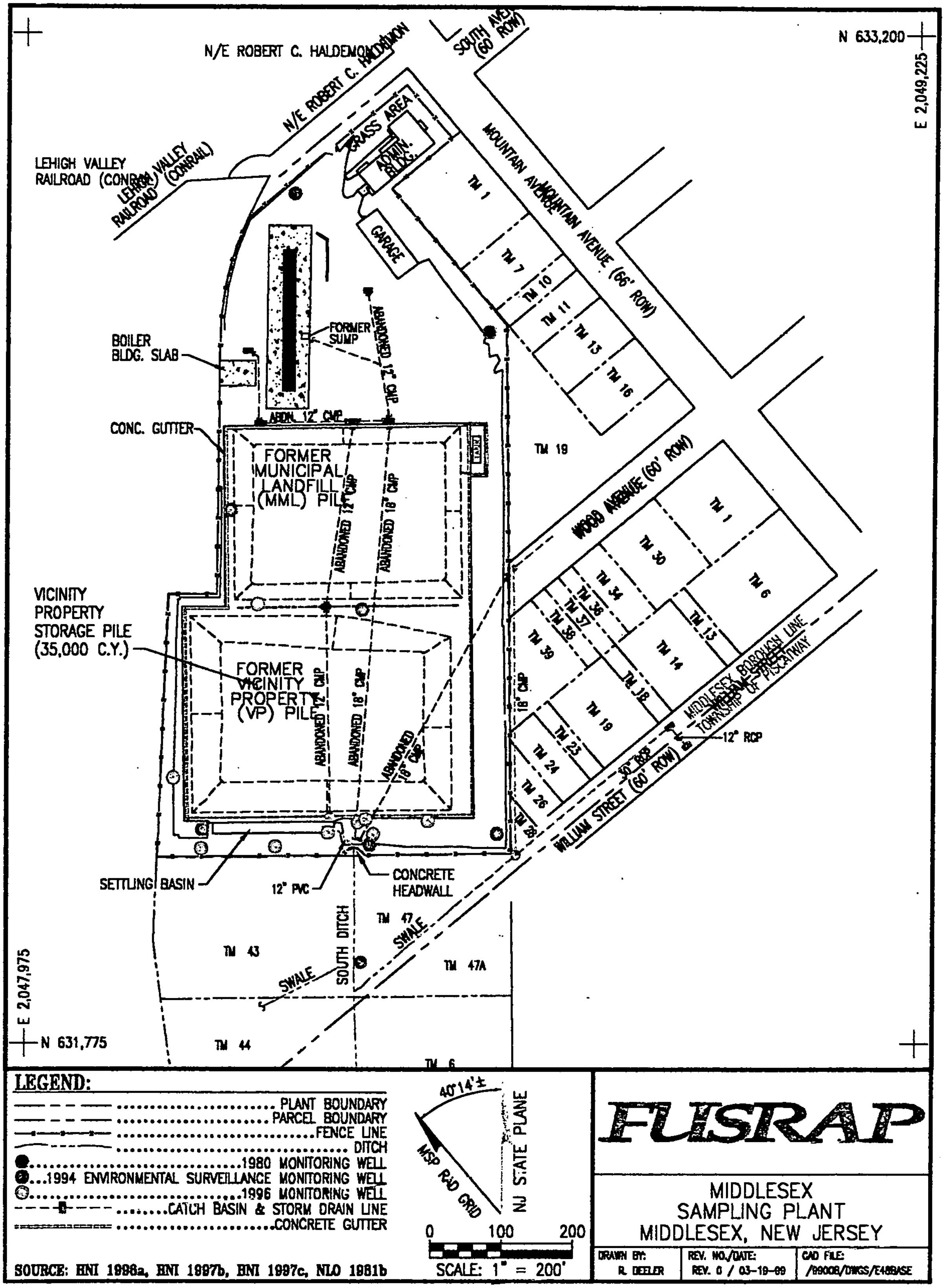
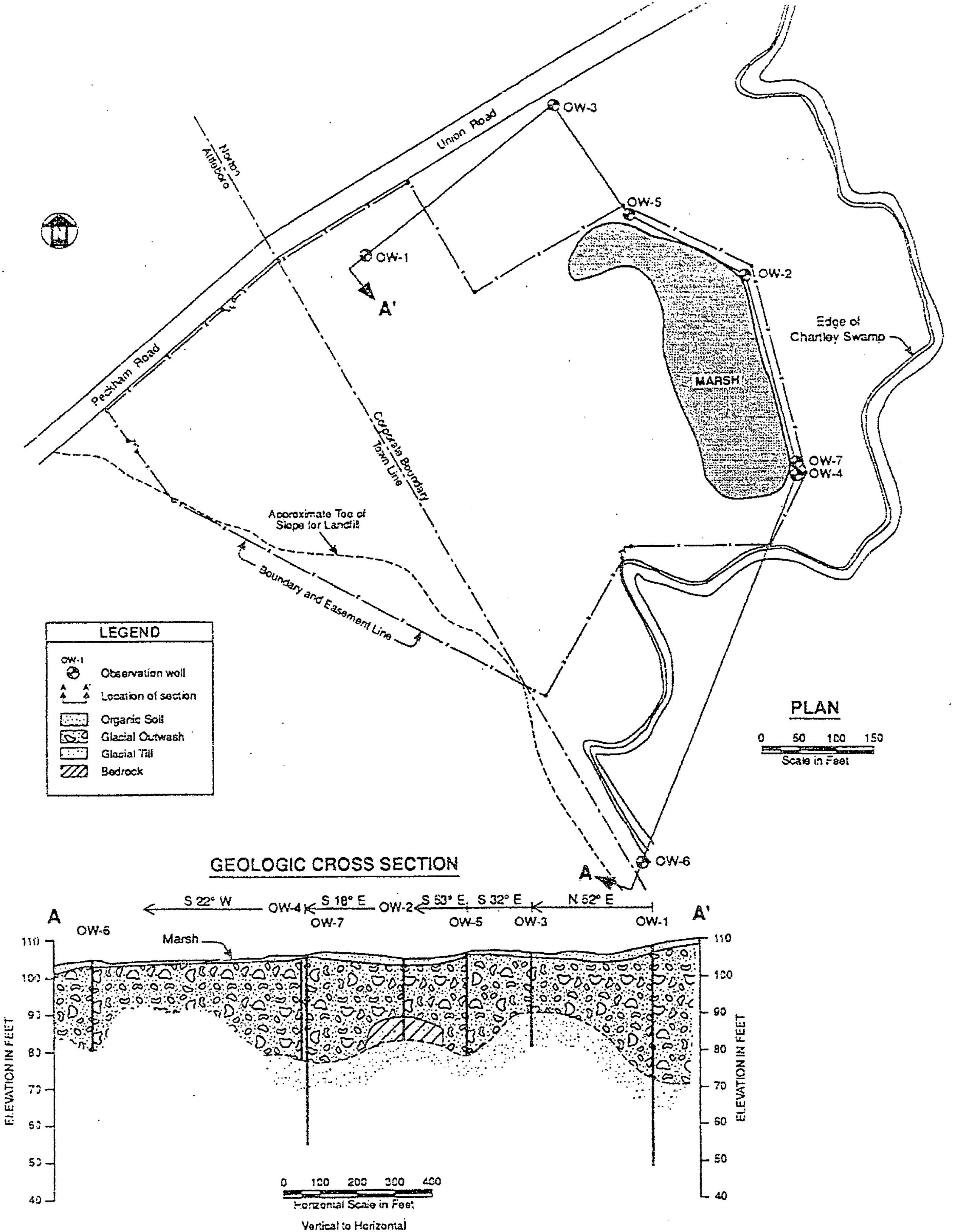


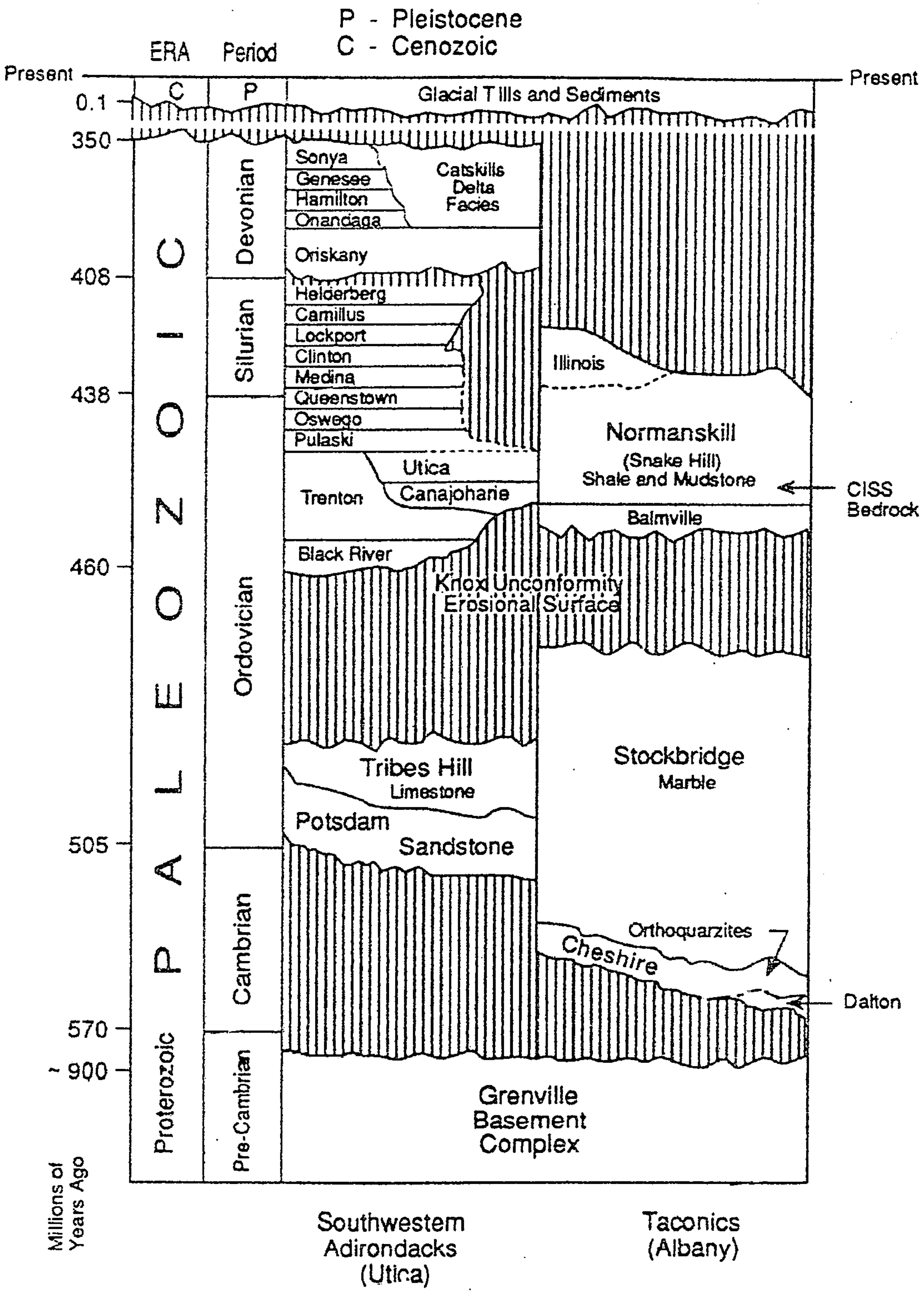
Figure 2-1. Present Layout of Middlesex Sampling Plant.



Source: BNI (1984)

Shpack Figure 3.1 Geologic Cross Section and Existing Monitoring Well Locations at the Shpack Landfill

SHPACK-891

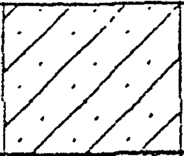
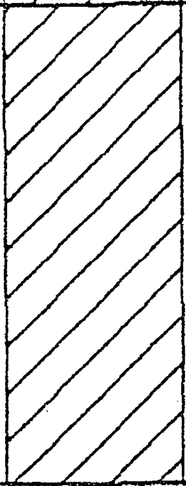
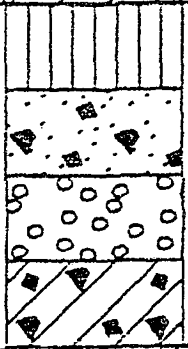
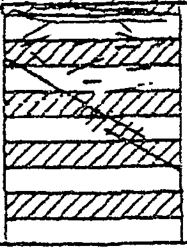


Note: Graphic representation of spatial and temporal relationships between formations. Does not indicate thickness.

Source: BNI 1992a

FUS/COLONIE-041692

CISS Figure 3.1

UNIT DESIGNATION	COLUMNAR SECTION	APPROX-IMATE THICKNESS (ft)	DESCRIPTION
TOPSOIL		0-1	[OH] - MODERATE BROWN SILTY CLAY OR CLAYEY SILT. DRY. ORGANIC WITH ROOTS AND DESICCATION CRACKS
GLACIAL OVERBURDEN CLAY		68-90	[CL] - MODERATE BROWN, DRY TO MOIST. DENSE. STIFF. MODERATELY PLASTIC. GRAVEL FRACTION TO 10%. THE SATURATED PORTION OF THE OVERBURDEN CLAY IS 0-20 FT THICK. NO ODOR. NO LAMINATIONS EVIDENT IN SAMPLES. HIGH DRY STRENGTH.
BASAL GLACIAL AND SILTY SAND AND CLAYEY GRAVEL		0-10	[ML] - SILTY SAND. SIMILAR IN APPEARANCE TO [SW] [GP] - POORLY SORTED GRAVEL. COARSE, SUBROUNDED, NON-COHESIVE, SATURATED. SHALE, GYPSUM, AND SOME QUARTZ. [SW] - MOSTLY OLIVE TO YELLOWISH BROWN. WELL SORTED. SATURATED SAND. NON-COHESIVE. SOFT. [GC] - CLAYEY GRAVEL. MODERATE BROWN. LARGE GRAVEL FRACTION (>50%) COARSE. SUBROUNDED. COHESIVE, SATURATED. VARIABLE HARDNESS.
EROSIONAL UNCONFORMITY			
CAMILLUS SHALE		± 200	GRAY CALCAHEOUS MUDSTONE WITH UP TO 50% THIN GYPSUM LAYERS. UPPER PORTION IS WEATHERED. BRITTLE. SOFT. LOWER PORTION IS FRESH. HARDER. SOLUTION CAVITIES ALONG BEDDING PLANES AND NEAR-VERTICAL JOINTS.

Tonawanda Figure 3.1 **Generalized Stratigraphic Column for the Tonawanda Area**

Cataloging Form

{Technical/Project Managers fill in C through G, K through Q. RM completes other fields}

A. Document ID Number: Assigned by database 00-363

B. *Further Information Required?:* ☐

C. *Operable Unit (Choose One):*
- USACE ☒
- ~~St. Louis Sites ☒~~
- Downtown ☐
- North County ☐
- Madison Sites ☐
- Inaccessible Areas ☐
- PRP ☐
- Oversight Committee ☐

D. *Site (Optional):*
- SLDS VPs ☐
- Mallinckrodt ☐
- SLAPS ☐
- SLAPS VPs ☐
- CWC ☐
- HISS ☐
- Madison ☐

E. *Area (Optional):* ____

F. *Primary Document Type (Choose One):*
- Site Management Records ☒
- Removal Response ☐
- Remedial Investigation ☐
- Feasibility Study ☐
- Record of Decision ☐
- Remedial Design ☐
- ~~Remedial Action ☒~~
- Public Affairs/Community Relations ☐
- Congressional Relations ☐
- Freedom of Information Act ☐
- Real Estate ☐
- Project Management ☐

G. *Secondary Document Type (see back of form):* ~~Remedial Action Documents~~ Archive Search Report

H. *Bechtel Number:* ____

I. *SAIC Number:* ____

J. *MARKS Number(Choose One):* FN: 1110-1-8100e ☐ FN: 1110-1-8100f ☐ FN: 1110-1-8100g ☑

K. *Subject:/Title:* Groundwater Report

L. *Author:* ____

M. *Author's Company:* ____

N. *Recipient(s):* ____

O. *Recipient(s) Company:* ____

P. *Version (Choose One):* Draft ☑ Final ☐

Q. Date: 5-22-99

R. *Include in the ARF?* ☑

S. *Include in the AR?* ☐

T. *Filed as Confidential/Privileged?* ☐

U. *Document Format (Choose one):*
- Paper ☑
- Electronic ☐
- Photographic ☐
- Audio-visual ☐
- Cartographic/Oversize ☐
- Microform ☐

V. *Filed in AR Volume Number:* ____

W. *Physical Location (Choose One):*
- Central Files ☑
- Records Holding Area ☐
- Microfilm Vendor ☐
- Department of Energy ☐
- In ARF ☐
- In AR ☐

X. *Associated with Document(s):* ____