US Army Corps of Engineers

FUSRAP

RECORD OF DECISION
GROUNDWATER OPERABLE UNIT OU2

MIDDLESEX SAMPLING PLANT FUSRAP SITE
MIDDLESEX, NEW JERSEY

FINAL, AUGUST 2021

PREPARED BY:

U.S. ARMY CORPS OF ENGINEERS
FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirement
bgs	below ground surface
CEA	Classification Exception Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Contaminant of Concern
CSM	Conceptual Site Model
CT	carbon tetrachloride
CTE	Central Tendency Exposure
DOH	Department of Health
ESV	Ecological Screening Value
FFA	Federal Facility Agreement
FS	Feasibility Study
FUSRAP	Formerly Utilized Sites Remedial Action Program
GAC	Granular Activated Carbon
HHRA	Human Health Risk Assessment
HI	Hazard Index
ISCR	In Situ Chemical Reduction
LUC	Land Use Control
MCL	Maximum Contaminant Level
MED	Manhattan Engineer District
µg/L	micrograms per liter
MML	Middlesex Municipal Landfill
MNA	Monitored Natural Attenuation
MSP	Middlesex Sampling Plant
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NPL	National Priorities List
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SE	Sampling Event
SEMS	Superfund Enterprise Management System
SLERA	Screening-Level Ecological Risk Assessment
SVOC	Semi-Volatile Organic Compound
TCE	trichloroethylene
WRA	Well Restriction Area

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

USACE	U.S. Army Corps of Engineers
USAEC	U.S. Atomic Energy Commission
USDOE	U.S. Department of Energy
USEPA	U.S. Environmental Protection Agency
VOC	Volatile Organic Compound

1.0 DECLARATION

1.1 Site Name and Location

Middlesex Sampling Plant (ID No. NJ0890090012)
239 Mountain Avenue
Borough of Middlesex, Middlesex County, New Jersey 08846-2518

1.2 Statement of Basis and Purpose

The Middlesex Sampling Plant (MSP) is no longer operational and is being addressed by the U.S. Army Corps of Engineers (USACE) under the Formerly Utilized Sites Remedial Action Program (FUSRAP). The MSP is listed on the U.S. Environmental Protection Agency's (USEPA's) National Priorities List (NPL) and in the Superfund Enterprise Management System (SEMS), with identification number NJ0890090012.

The MSP site is broken down into two Operable Units (OUs) that address independent portions of the site conditions:

- **Soils OU1**: The Soils OU1 has been addressed as a separate action, and a Record of Decision (ROD) was signed in September 2005 (USACE 2005a). The Selected Remedy for OU1 was completed in 2008, which included removing the source of contaminants of concern (COCs) in the soil and contaminants in the overburden aquifer as part of the dewatering efforts.
- **Groundwater OU2**: The Groundwater OU2 was originally composed of sediment, surface water, and groundwater. However, based on the findings presented in the previous groundwater investigation reports and the results of the risk assessments completed at the MSP site (see Section 2.7), the risk associated with exposure to MSP site sediments and surface water were found to be within the risk range identified in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) as 1×10^{-4} to 1×10^{-6} and the goal of protection of a hazard quotient or hazard index equal to 1, such that no remedial action is required for these media. Therefore, this ROD only addresses groundwater for OU2, which includes elevated concentrations of volatile organic compounds (VOCs) in bedrock groundwater and residual levels of uranium groundwater contamination in the overburden groundwater remaining after the remediation of OU1.

This decision document presents the Selected Remedy for the Groundwater OU2 at the MSP site. The Selected Remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, and the NCP. The USACE, as the lead agency, has issued the final remedy selection decision for the Groundwater OU2 at the MSP site and this ROD documents that decision (NCP §300.430(f)(4)(i)).

The remedy was selected based on the information contained in the Administrative Record for this site and is jointly selected by the USACE and USEPA in consultation with the New Jersey Department of Environmental Protection (NJDEP). Comments on the Proposed Plan for the groundwater at the MSP site provided by the USEPA and NJDEP were evaluated and considered during the selection of the final remedy. The Administrative Record is maintained at the Middlesex Public Library, 1300 Mountain Avenue, Middlesex, New Jersey 07016.

1.3 Assessment of the Site

The Selected Remedy described in this ROD is necessary to protect the public health or welfare and the environment from actual or threatened releases of hazardous substances and/or pollutants or contaminants from this site, which may present an imminent and substantial endangerment to public health or welfare.

1.4 Description of Selected Remedy

The remedy described in this document represents the second of two planned remedial actions for the FUSRAP MSP site. The remedial action for Soils OU1, which addressed the remediation of contaminated soils and debris (e.g., soil, fill, and below-grade structures), was completed in 2008. This ROD for OU2 will address groundwater contamination associated with early atomic energy program activities at the MSP site.

The remedial action for OU2 addresses groundwater contaminated with FUSRAP waste at MSP under CERCLA. To address the contaminated groundwater, the selected remedy consists of a combination of remedial technologies to treat contaminants present at the site. Alternative 3 was identified as the selected remedy and includes treatment with in-situ chemical reduction (ISCR), monitored natural attenuation (MNA), and land use controls (LUCs). The ISCR technologies will treat the VOCs present in groundwater situated in the fractured bedrock onsite at the source area. This treatment would eventually eliminate VOCs emanating from the site source area and leave behind groundwater with low concentration VOCs in the downgradient portion of the plume. It is estimated that cleanup levels will be achieved in the source area within a 10-year timeframe.

MNA will address: the on-site low concentration of VOCs that are not addressed by the active treatment; the downgradient portion of the VOC plume; and the total uranium present in the overburden. The timeframe for MNA is estimated as 30 years, but will be refined during the Remedial Design. The specifics of the monitoring program will be developed in a long-term monitoring plan. CERCLA Five-Year Reviews will be required to continue as long as hazardous substances, pollutants, or contaminants remain above levels that allow unlimited use and unrestricted exposure.

LUCs will be implemented to eliminate or minimize the potential for human exposure at unacceptable levels by direct contact or ingestion of groundwater. LUCs will consist of both well restrictions in a New Jersey groundwater Classification Exception Area /Well Restriction Area (CEA/WRA), where groundwater contamination has been identified, and physical LUCs such as posting construction worker warnings that have been issued regarding dermal exposure. CEA/WRAs are institutional controls in geographically defined areas within which the New Jersey Groundwater Quality Standards (NJGWQS) for specific contaminants that have been exceeded. Designated aquifer uses are suspended in the affected CEA/WRA for the term of the CEA/WRA. CEA/WRAs are administered by the State of New Jersey. The state exercises its authority by utilizing a statute that requires the issuance of permits prior to the construction of any groundwater well.

A CEA/WRA proposal form and support information with approved site plume boundary shape file has been submitted to NJDEP, in order for NJDEP to establish the site CEA/WRA. The

CEA/WRA will remain in effect until the concentrations of VOCs in the aquifer are below the applicable NJGWQS, which have been selected as cleanup levels.

The Selected Remedy will be considered complete once groundwater monitoring indicates that COCs are at, or below, Applicable or Relevant and Appropriate Requirements (ARARs) (i.e., cleanup levels) in on-site and off-site groundwater monitoring wells. The standard methods of demonstrating achievement of groundwater remediation cleanup levels would be used per the USEPA Guidance*, Recommended Approach for Evaluating Completion of Groundwater Restoration Remedial Actions at a Groundwater Monitoring Well* (USEPA 2014) (see Section 2.8 for more details). The guidance recommends evaluating COC concentration levels on an individual well-by-well basis to assess whether aquifer restoration is complete.

1.5 Statutory Determinations

Statutory Requirements

The Selected Remedy is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action, is cost-effective, and utilizes permanent solutions to the maximum extent practicable.

Statutory Preference for Treatment

The Selected Remedy will satisfy the statutory preference for treatment as a principal element. ISCR is planned to treat the VOCs present in groundwater situated in the fractured bedrock onsite at the source area and MNA is planned to address the on-site low concentrations of VOCs that are not addressed by the active treatment; the downgradient portion of the VOC plume; and the total uranium present in the overburden.

Five-Year Review Requirements

CERCLA Five-Year Reviews will continue as long as hazardous substances, pollutants, or contaminants remain above levels that allow unlimited use and unrestricted exposure.

ROD Data Certification Checklist

The following information is presented in Section 2, Decision Summary:

- Potential land and groundwater use that will be available at the MSP as a result of the Selected Remedy (Section 2.6);
- Current and reasonably anticipated future use assumptions used in the Human Health Risk Assessments (HHRAs) and Screening-Level Ecological Risk Assessment (SLERA) (Section 2.7);
- Baseline risks from the COCs (Section 2.7);
- The ARARs established for the COCs and their basis (Section 2.8);
- The COCs and their respective concentrations (Section 2.8.2);
- The key factors that led to the selection of the remedy (Sections 2.9, 2.10, 2.11, and 2.12);

- How source materials constituting principal threats are addressed (Section 2.11.10); and,
- The summarized estimated costs of the Selected Remedy (Section 2.12.3).

1.6 Authorizing Signatures

BAKER.KAREN.J.1137993380 Digitally signed by BAKER.KAREN.J.1137993380 Date: 2021.08.20 11:50:25 -04'00'

20 Aug 2021

Karen J. Baker
Programs Director
USACE North Atlantic Division

Date

Evangelista, Pat Digitally signed by Evangelista, Pat Date: 2021.09.09 14:47:01 -04'00'

9 September 2021

Pat Evangelista
Director, Superfund and Emergency Management Division
U.S. Environmental Protection Agency

Date

2.0 DECISION SUMMARY

2.1 Site Name, Location, and Brief Description

The MSP is approximately 9.6 acres and is located at 239 Mountain Avenue in the Borough of Middlesex, Middlesex County, New Jersey. MSP is located approximately 20 miles southwest of Newark, New Jersey, and approximately 30 miles southwest of New York City (see Figure 2-1). The area within 0.50 miles of the MSP is a mixture of residential homes, commercial and industrial properties, and undeveloped land. The MSP is bordered to the east by residential and commercial properties, to the south by residential property, including condominiums, , to the west by an auto salvage facility and other commercial property, and to the north by a railroad right-of-way beyond which is residential property. The MSP is zoned as industrial by the Borough of Middlesex Planning Commission. The MSP is currently vacant land with grass cover and includes a gravel access road on the east side of the property. A 7-foot chain-link fence surrounds the MSP, restricting public access.

The MSP is no longer operational and was placed on the USEPA's NPL in 1999 under the Federal Facilities program (USEPA ID No. NJ0890090012). The USACE was delegated the authority to clean up the site under FUSRAP by the Energy and Water Development Appropriations Act of 1998, and subsequent appropriations acts. The USACE is the lead agency for site activities and USEPA Region 2 is the support agency with lead oversight responsibilities. In September 2009, the USEPA, USACE, and the U.S. Department of Energy (USDOE) entered into a Federal Facility Agreement (FFA) for MSP, which delineated roles and responsibilities for the three agencies.

2.2 Site History and Enforcement Activities

Activities Leading to Current Problems

The MSP was originally developed in 1910 (original company unknown) as an industrial plant for the manufacturing of asphalt paint. The plant included a brick warehouse, boiler house, garage, administration building, dye warehouse, and four smaller buildings. In 1913, American Marietta Company, which sold products under the name American Asphalt Company, purchased the original company that began operations on the MSP.

During October 1943, the Manhattan Engineer District (MED) leased the brick warehouse from the American Marietta Corporation and converted it into a process building to sample, store, test, and transfer ores containing uranium, thorium, and beryllium. Between 1943 and 1955, analysis of ores for uranium was the primary operation conducted at MSP by United Lead Company, which was a subcontractor of the MED/U.S. Atomic Energy Commission (USAEC). Uranium ores were received in burlap bags that were stacked and stored on the ground. The ore was thawed (if necessary), dried, crushed, screened, and collected in hoppers, the contents of which were then sampled for analysis. Ores were then packaged, weighed, and shipped to processing facilities.

The property was leased by the US Government (MED) from American Marietta Corporation from October 1943 until September 1946. After that time the US Government was awarded the property by condemnation in 1946. During this period, various new buildings were constructed, including replacements for the administration building and garage, a thaw house, and a storage house. A

chain-link fence was installed to surround the MSP, and most of the property was paved with asphalt for use as a drum storage area.

Throughout the late 1940s and early 1950s, the MSP received and shipped various research and decontamination wastes and incinerated low-level combustible waste at the MSP. The incinerated ashes and noncombustible scrap were allegedly placed in drums and transported off site for disposal.

During 1951 and 1952, the MSP became an intermediate point for shipment of uranium bars to a location off-site where the bars were experimentally machined into slugs. Scraps from this operation were then returned to the MSP for shipment to a uranium recovery processor. Over the years that the MSP was operational, the buildings, soils, and groundwater, as well as nearby land parcels, became contaminated with radium and uranium. The handling of uranium ore sacks likely resulted in spillage, and subsequent migration mechanisms such as precipitation, runoff, and infiltration caused localized radiological contamination both on and off site.

The USAEC ceased primary operations at the MSP in 1955. However, the MSP continued to be used for storage and limited sampling of thorium residues. All USAEC activities at the MSP were terminated in September 1967 after decontamination of the structures and certification of the MSP for unrestricted release was complete. In 1968, the USAEC returned the MSP property to the General Services Administration, which then transferred the property to the U.S. Department of the Navy. The MSP served as a U.S. Marine Corps reserve training center from 1969 to 1979 before it was placed back in the custody of the USDOE in 1980. The MSP, no longer operational, is being addressed as a USACE FUSRAP site.

The USAEC, a predecessor to the USDOE, established FUSRAP in 1974 to identify, remediate, or otherwise control sites contaminated with residual radioactivity resulting from activities of the MED and early operations of the USAEC. The goal of FUSRAP is remediation of sites contaminated as a result of the nation's early atomic energy program in accordance with the CERCLA. Responsibility for execution of response actions on sites included in FUSRAP was transferred from the USDOE to USACE by Public Law 105-62 (October 13, 1997), and long-term programmatic authority was specifically provided to USACE in Public Law 106-60, Section 611, on September 29, 1999. This authorized the USACE to conduct remediation of sites contaminated as a result of the nation's early atomic energy program. On February 18, 1999, the MSP site was added to the NPL in the Federal Facilities Section.

Site Investigations

Numerous radiological investigations have been conducted at the MSP. In 1967, after decontamination and before release of the site by the USAEC, the MSP was radiologically surveyed and found suitable for release for unrestricted use according to the standards in place at the time. Due to a lack of documentation of the radiological status of the property after its release and the implementation of the "as low as reasonably achievable" policy, the MSP was resurveyed for radiological constituents in 1976 by the Oak Ridge National Laboratory (ORNL). The results of this study identified radiological contamination above then-current guidelines at the MSP and vicinity properties.

An environmental surveillance program was established through FUSRAP at the MSP in 1981 to identify and quantify the effect of site removal action activities initiated by the USDOE in 1980 on the surrounding environment and public health. This was done to help ensure that the environment and public health were protected from contamination present on the site. The environmental surveillance program included the periodic sampling of air, surface water, sediment, and groundwater and was completed in 2007. Results of this program are described below.

A 1983 radiological survey was conducted by Bechtel National Inc., through the USDOE to prepare for future remediation at MSP. The survey estimated the area and depth of radiological contamination on the grounds and under the process building, boiler house, administration building, and garage. Contaminated soils were identified around and under the process building and were found to extend south, past the former thaw house. The highest contamination levels were found near the process building and in the southern portion of the MSP.

In November 1991, a chemical characterization study was conducted by Bechtel National Inc., through the USDOE on both the vicinity properties and Middlesex Municipal Landfill (MML) piles and in situ soils. These piles were the result of interim cleanup actions at the MML and at properties in the vicinity of MSP. Target Analyte List metals (except cyanide), lanthanides, polychlorinated biphenyls, total petroleum hydrocarbons, and Resource Conservation and Recovery Act (RCRA) toxicity characteristic constituents were selected for analysis in the vicinity property pile and MML pile samples. In situ soil samples were analyzed for VOCs, semi-volatile organic compounds (SVOCs), and pesticides.

In August 1995, an investigation was completed by Bechtel National Inc., through the USDOE to evaluate the fill behind the outfall headwall of the surface water drainage system. The sampling results from the investigation indicated soil contamination behind the headwall in the fill material to a depth of approximately 5 feet below ground surface (bgs). Subsequent results from gamma logging indicated radioactive contamination in the drain lines or the fill around the drainage pipes.

The results of these investigations were used to plan the MSP Soils OU1 RI. The Soils OU1 RI, which provides the basis for the Soils OU1 FS, was initiated in 2000. It included extensive surface and subsurface soil sampling and analysis for radiological and chemical contamination. SVOCs, lead, and radionuclides were identified in these investigations as COCs, which contribute to unacceptable human health risks. All contaminated site media (i.e., surface and subsurface soils, asphalt pads, and demolition debris) were removed from the MSP site to established cleanup levels per the Soils OU1 ROD. The site media were disposed of off-site at an approved, licensed, or permitted facility. Excavation and off-site disposal of radiologically and chemically contaminated soil as part of the Soils OU1 remedial action was completed in June 2008. The removal of the contaminated media has resulted in the removal of potential sources that may further impact the groundwater. However, residual levels of groundwater contamination were expected to remain. Following the removal activities, post-remedial action measurements were collected to verify if cleanup levels were attained.

Groundwater investigations conducted at the MSP site include: the Groundwater OU2 RI conducted in 2000 to 2002 (USACE 2005b); a supplementary groundwater investigation conducted in Fall 2004 to further delineate the extent of the contamination (see Appendix B in

USACE 2017a); and, supplementary bedrock groundwater investigations conducted from 2008 to 2016 (USACE 2017b). Figure 2-2 includes the locations of the groundwater monitoring wells. The groundwater COCs for OU2 include elevated concentrations of VOCs in bedrock groundwater [carbon tetrachloride (CT), trichloroethylene (TCE), and chloroform] and minor residual levels of radioactive groundwater contamination in the overburden groundwater unit (uranium) [please refer to Section 2.8.2 for more details regarding the COCs].

The release area for CT, chloroform (a breakdown product of CT), and TCE appears to be limited to a small sump that was located in the former Process Building. This sump was used to dispose of wastewater and may have been used for the disposal of non-water residuals, although site records do not indicate the use of solvents as part of site operations. This sump was 12 feet long, 6 feet wide, and 10 feet deep and had a feeder line leading from it to the main pipe storm water line. Records indicate that the sump was open and in communication with groundwater. The bottom of the sump would have been near the interface of the overburden groundwater unit and on top of the unsaturated weathered bedrock, providing a migration pathway directly to the bedrock aquifer.

Site Remedial Actions

During 1976, due to changes in radiological standards and release guidelines, the MSP was re-evaluated for residual radioactive contamination (ORNL 1977). The MSP was placed back in USDOE custody in 1980 after contamination above the then-current guidelines was found at MSP and at surrounding vicinity properties, both residential and commercial. Residual contamination that originated from the MSP was also identified at the MML. This contaminated landfill material resulted from construction activities in 1948 when excess soil from grading operations at the MSP containing small amounts of pitchblende ore (high-grade uranium ore) was taken to the MML. The contaminated material was subsequently covered to varying depths during landfill operations.

The USDOE initiated Phase I of an action to address the vicinity properties in 1980. Two of these parcels, a church rectory and a residence less than a mile from the MSP, had been contaminated by fill that was transported from the MSP site during a 1948 site grading program. Contaminated fill that was also transported to the MML during 1948 subsequently required cleanup as well. As part of the Phase I activities, an asphalt pad was constructed at the south end of the MSP to accommodate placement of the waste materials from property cleanups in the vicinity. Improvements to the on-site drainage system were also made at this time. The old drainage system was replaced with a new system to collect surface water runoff in a below-grade settling basin prior to its discharge to the south drainage ditch.

The Phase II cleanup addressed the remaining contaminated parcels. Residual radioactivity was found in parcels of land adjacent to the site and along both the South Drainage Ditch and the Main Stream.

Cleanup of the vicinity properties and the MML was initiated by the USDOE in 1981 and was completed in 1986 (Bechtel National, Inc. 1985a, 1985b). The excavated materials generated from these actions were temporarily stored on specially constructed pads at the MSP in two piles, the vicinity properties and MML interim storage piles. As their names imply, the vicinity property pile contained the excavated materials from the cleanup of the vicinity properties (a total of 35,200

cubic yards), and the MML pile contained the excavated materials from the cleanup of the MML (a total of 31,200 cubic yards). The vicinity properties and MML piles were the subject of CERCLA removal actions conducted by the USACE. As a result, the waste materials were transported to approved off-site licensed or permitted disposal facilities pursuant to an action memorandum by USACE officials in 1997 and 1999 (USACE 2017a). The MML pile was removed in 1998, and the vicinity property pile was removed in 1999.

Cleanup of contamination under the Soils OU1 ROD at MSP began in September 2006 and was completed in May 2008. The COCs identified in the Soils OU1 ROD are benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, lead, radium-226, thorium-230, uranium-234, uranium-235, and uranium-238.

Approximately 40,700 cubic yards of radiological waste and 4,280 cubic yards of non-radiological waste were excavated and transported to an approved off-site permitted or licensed disposal facility during the soils remedial action. Additionally, clean backfill material was placed in excavation areas. No remedial/removal actions were conducted for groundwater at MSP; however, approximately 1.5 million gallons of water were removed from the excavation, treated, and discharged in accordance with the Soils OU1 ROD during the soils remedial action.

2.3 Community Participation

Community participation activities provide the public with an opportunity to express its views on the remedial action. The USACE and USEPA considered state and public input from community participation activities when they selected the remedial alternatives to be used for the MSP site. Community participation was provided in accordance with CERCLA, as amended by SARA.

The Groundwater OU2 Proposed Plan for MSP was made available to the public on 24 August 2020. This document, along with the Groundwater OU2 Groundwater Investigation Technical Memorandum, Remedial Investigation (RI)/Feasibility Study (FS), and other related information that have been performed as part of this CERCLA response action are contained in the Administrative Record for the site and are maintained at the following locations:

USACE New York District
26 Federal Plaza, Room 17-401
New York, NY 10278

And,

Middlesex Public Library
1300 Mountain Avenue
Middlesex, New Jersey 08846
(732) 356-6602

In August 2020, the Middlesex Public Library was temporarily closed due to COVID-19; however, the Proposed Plan was posted online for review and public comment on the following USACE webpage:

https://www.nan.usace.army.mil/Media/Fact-Sheets/Fact-Sheet-Article-View/Article/487433/fact-sheet-middlesex-sampling-plant-msp/

The notice of availability for the documents was published in the Home News Tribune on 17 August 2020 and 24 August 2020, and in the Star Ledger on 19 August 2020. The public comment period was held from 24 August 2020 through 25 September 2020.

Due to the current global COVID-19 pandemic, the public meeting could not be held in person at the Middlesex Public Library. Instead, USACE presented the information during an online meeting (in accordance with the USEPA's latest virtual meeting guidance). The virtual meeting was held on 31 August 2020 at 6:00 pm.

At the public meeting, representatives from USACE provided information and answered questions about contamination at the MSP and the remedial alternatives under consideration. There were no oral comments received during the virtual meeting nor any written comments submitted to USACE during the public comment period. A transcript of the public meeting is available to the public and has been included in the Administrative Record and Information Repository.

2.4 Scope and Role of Operable Unit or Response Action

The Groundwater OU2 RI/FS addressed sediment, surface water, and groundwater associated with the MSP site. However, based on the findings presented in the previous groundwater investigation reports and the results of the risk assessments completed at MSP (see Section 2.7), the risk associated with exposure to site sediments and surface water were found to be within the USEPA's risk management range, such that no remedial action is required for these media. Therefore, this ROD only addresses groundwater COCs for OU2 including elevated concentrations of VOCs in bedrock groundwater (CT, TCE, and chloroform) and minor residual levels of radioactive groundwater contamination in the overburden groundwater unit (uranium). [Please refer to Section 2.8.2 for more details regarding the COCs.]

2.5 Site Characteristics

2.5.1 Conceptual Site Model

A summary of the contaminant fate and transport processes has been developed by using available data to characterize and develop a conceptual understanding of the flow systems at work at the MSP. The Conceptual Site Model (CSM) is presented as Figure 2-3.

A CSM is a written or illustrative representation of the chemical and physical processes that control the fate and transport of contamination, and the potential receptors impacted by that contamination. The model incorporates hydrologic data, site physical characteristics, infiltration/recharge, and surface water drainage patterns. The conceptual model provides a mechanism where observations can be compared, and predictions can be made for potential exposure locations. The predictive function of the MSP conceptual model, of primary importance to contaminant fate and transport analysis, relies on known information and assumptions about the MSP.

Two subsurface flow systems are present at the MSP. Groundwater flow in the overburden in the northern one-third of the site is generally north to northeast and northwest, toward a railroad right-

of-way with a typical gradient of 0.008 to 0.016. In the southern two-thirds of the MSP, shallow groundwater flow is generally to the south to southeast with a gradient of 0.01 to 0.02 and a hydraulic conductivity of 2.7 feet/day. A potentiometric surface contour map for the overburden wells (December 2015) is included as Figure 2-4.

The groundwater aquifer in the shallow bedrock at the MSP occurs 15 to 50 feet below grade and is at least 50 feet thick. Groundwater flow in the bedrock unit is generally west to northwest with a low hydraulic gradient of 0.008 to 0.012 and low hydraulic conductivity of 1.5×10^{-1} feet/day. A potentiometric surface contour map for the shallow bedrock wells (Unit B) (December 2015) is included as Figure 2-5. The shallow bedrock is separated from the overburden flow system by the extremely weathered bedrock, which serves as a leaky aquitard (confining layer), with many of its fractures filled with silt and clay.

South of the MSP, potential receiving water bodies of groundwater from the overburden system include the South Drainage Ditch, the wetlands area adjacent to the South Drainage Ditch, and Main Stream (see Figure 2-6). Once groundwater discharges to these receptors, it can move via overland flow to Ambrose Creek, which in turn discharges to the Raritan River, approximately one mile from the MSP. Groundwater in the overburden is not used for water supply. To the north, groundwater in the overburden may discharge intermittently to a drainage ditch in the railroad right-of-way, which in turn, during periods of heavy runoff, flows to Ambrose Creek and eventually to the Raritan River. Groundwater in the shallow bedrock flows north-northwest and is carried deeper via dipping bedding planes and fractures as it moves off site with no surface waterbodies or topographic features in the area to serve as a potential discharge point. Some local area residents use groundwater from the bedrock as a source of water, but based on an investigation by USACE (refer to Section 2.6), none are known to be within the plume identified as emanating from the MSP.

The release area and source for the CT and TCE (and the breakdown product chloroform) appears to be limited to a small sump that was located in the former Process Building (see Figure 2-2). This sump was used to dispose of wastewater and may have been used for the disposal of other liquids, although site records do not indicate the use of solvents as part of site operations. This sump was 12 feet long, 6 feet wide, and 10 feet deep and had an overflow line that connected into the stormwater conveyance system. Records indicate that the sump was open and in communication with groundwater (overburden). The bottom of the sump would have been near the interface of the overburden groundwater unit and on top of the unsaturated weathered bedrock, providing a migration pathway directly to the bedrock aquifer. Residuals disposed of at this depth would have spread downward and outward from this point along fractures and partings within the unsaturated bedrock before reaching the water table. The potential for migration of VOCs from groundwater into indoor air was evaluated and was determined not to pose a risk because the pathway does not exist at this site. As discussed, contaminated groundwater is carried deeper into the aquifer as it moves off site and overlying “clean” groundwater prevents volatilization into subsurface unsaturated zones.

Based on historical analytical data gathered as part of the RI and the 2016 Groundwater Investigation Technical Memorandum, uranium contamination is located in the shallow overburden groundwater unit that generally lies within 10 feet of the ground surface. The overburden groundwater contamination came from a uranium release at the surface, which leached

from soils that have since been removed during the soils remedial action in 2008. The Groundwater Investigation Technical Memorandum describes the uranium concentrations trending below the Maximum Contaminant Level (MCL) (USACE 2017b).

2.5.2 Sampling Strategy

Numerous groundwater investigations have been conducted at the MSP site. The following subsections summarize activities associated with these events. For more information on the Environmental Surveillance, Groundwater OU2 RI, and the Off-Site Delineation Investigation, please refer to the respective reports (USACE 2000, 2005b, 2017b).

2.5.2.1 Environmental Surveillance

Environmental surveillance groundwater samples were collected from a monitoring network of wells from 1994 to 2008. Groundwater samples collected during each of the environmental surveillance events were analyzed for VOCs, SVOCs, metals, and radionuclides. Surface water and sediment samples collected during environmental surveillance events were analyzed for SVOCs, metals, and radionuclides.

The environmental surveillance program ended in 2008 and was replaced with groundwater monitoring sampling events (SEs), which evaluated both the uranium and VOCs detected in groundwater (see Tables 2-1 and 2-2) (USACE 2017b). A total of 16 SEs were conducted from August 2008 (SE 1) to January 2016 (SE 16). VOCs detected in groundwater have generally been identified in the bedrock units (USACE 2000).

2.5.2.2 Groundwater OU2 RI

From February to September 2001, the following work was completed as part of the groundwater OU2 RI:

- Groundwater samples were collected from seventeen overburden and seven bedrock monitoring wells;
- Two overburden groundwater samples were collected within the South Drainage Ditch area from temporary well points using Hydropunch® technology;
- Two background groundwater monitoring wells (URS-MW-20S and URS-MW-20D) were installed off site and samples were collected; and
- All the samples were analyzed for VOCs, SVOCs, metals, and radionuclides.

2.5.2.3 Off-Site Delineation Investigation

In November 2004, in support of the Groundwater OU2 FS, a supplemental off-site delineation investigation was performed (USACE 2017a). Figure 2-2 includes the locations of the MSP groundwater monitoring wells. This investigation included the following:

- The installation and sampling of eight temporary well points (Hydropunch®) for VOCs and radionuclides.

- The installation and sampling of nine piezometers (two of which were subsequently turned into monitoring wells) for VOCs and radionuclides.
- The installation and sampling of four monitoring well clusters, each containing one overburden well and one bedrock well (total of eight new wells), as well as five additional perimeter wells. The samples were analyzed for VOCs, SVOCs, metals, and radionuclides.

2.5.2.4 Supplemental Bedrock Groundwater Investigation

The groundwater investigation initially addressed only radioactive groundwater contamination. However, the groundwater data indicated persistent elevated levels of VOCs in two of three bedrock wells (MW-26 and MW-27). These wells are located downgradient of the Process Building. After evaluating these results, the USACE determined that installation of additional bedrock monitoring wells and sampling for VOCs would be necessary to characterize the vertical and horizontal extent of the MSP site contamination.

From 2010 to 2012, the hydrogeologic characteristics of the shallow bedrock were investigated at the onset of this effort to aid in delineating the extent of the VOC contamination at the site. These objectives were accomplished by installing bedrock test holes, collecting depth discrete samples, completing various geophysical borehole tests, aquifer testing, and installing additional bedrock monitoring wells for sampling.

From 2013 through 2016, investigations of the bedrock aquifer focused on determining the extent of VOC contamination that impacted the bedrock aquifer. The investigation identified three transmissive fractures or bedding planes that contained VOC contamination, and these were named Unit B, Unit C, and Unit D for simplicity to reference (see Figure 2-2). Wells were placed in Units B, C, and D, with well screen lengths ranging from 10 to 25 feet in length. Unit B is the shallowest bedrock fracture/bedding plane and where the highest concentrations of VOCs were found. Units C and D are deeper, parallel, fracture/bedding plane units that are located about 25 feet and 80 feet beneath Unit B, respectively. The concentrations of VOCs detected in these units are much lower than those detected in Unit B, with concentrations in Unit C higher than concentrations in Unit D. The VOCs investigated at the site were primarily CT, TCE, and chloroform. This action was completed in early 2016.

In 2014 and 2015, two additional groundwater sampling events (SE 15 and SE 16) were conducted, and the monitoring wells were sampled for VOCs (both overburden and bedrock wells) and uranium (overburden wells only). High concentrations of VOCs were detected in the samples from bedrock wells but not from overburden wells. Although uranium was detected in overburden wells, the concentrations were below the USEPA MCL for drinking water. The low levels of uranium in the overburden groundwater samples indicate that only residual uranium from past operations remains in the overburden. This trend was expected after the removal of on-site soils during the OU1 remedial action completed in 2008.

2.5.3 Sources, Types and Extent of Contamination

The following text summarizes groundwater investigation results by contaminant category.

2.5.3.1 Summary of VOCs in Groundwater (Overburden and Bedrock)

The VOCs found in the MSP site groundwater at elevated levels included: tert-butyl-alcohol, methyl-tert-butyl-ether, tetrachloroethene, methylene chloride, CT, TCE, 1,1-dichloroethene (1,1-DCE), and chloroform. For one or more of the following reasons, the VOCs tert-butyl-ether, methyl-tert-butyl-ether, tetrachloroethene, 1,1-DCE, and methylene chloride were not identified as COCs because: (1) their presence in wells located in the upgradient portion of the site, adjacent to an auto salvage yard, indicates migration from an off-site non-FUSRAP source; (2) they are not related to past FUSRAP on-site activities; (3) they were not determined to present a risk to human health; or (4) some VOCs, such as methylene chloride, acetone, 2-butanone, and toluene, are identified in the Risk Assessment Guidance for Superfund Part A (USEPA 1989) as commonly used organic chemicals in the laboratory and may be introduced into a sample from laboratory cross-contamination, not from the site, and thus can be excluded. Additionally, the organic compounds associated with potential laboratory cross-contamination were noted in both the RI/Baseline HHRA and Supplemental HHRA as being detected in either laboratory, reagent, and/or trip blanks and did not impact the overall data usability or conclusions of these assessments.

CT and TCE are the most prevalent VOCs detected at MSP and the surrounding area, although other chlorinated compounds and their breakdown components and petroleum-related compounds have been detected in samples collected from the monitoring well network. Chloroform is a breakdown product of CT and is likely present only as a result of natural degradation of the CT. Shallow bedrock wells containing CT on the MSP site and bordering the site have typically exhibited a significantly higher concentration of CT than TCE. No other VOCs were detected in on-site monitoring wells at concentrations that indicated a potential that they had been released to the environment on the MSP property.

No shallow sources of CT and/or TCE were detected in the overburden groundwater screening or monitoring well samples. The highest groundwater concentrations of CT and TCE were detected in samples collected from Unit B and shallow bedrock wells, the extent of which is shown in Figure 2-6b.

As shown in Table 2-2, the highest concentrations of CT, TCE, and chloroform have been detected in ECC-MW30B, but the concentrations have been decreasing consistently and significantly since this well was first sampled in 2012. EE-MW-41S showed a similar trend between the only two times this well was sampled in 2014 and 2015.

Both wells ECC-MW-30B and EE-MW-41S, located in the vicinity of the sump (Figure 2-2), were installed with 10-foot well screens within the shallow bedrock aquifer to depths of 53 feet bgs and 30 feet bgs, respectively. Samples collected from wells installed at these depths would be expected to have lower VOC concentrations than samples collected from shallower or upgradient bedrock wells nearer to release areas (surface). Upgradient screening samples collected from Unit B and overburden groundwater did not exhibit significant concentrations of VOCs. The significant reduction in CT, chloroform, and TCE concentrations observed in on-site wells ECC-MW-30B and EE-MW-41S indicates that the initial elevated concentrations of these contaminants may have been a secondary effect of drilling through minor residual contaminants in the unsaturated portion of the weathered bedrock, beneath the limits of the remedial excavation of site soils (OU1 remedial action). Thus, groundwater screening samples and monitoring well samples collected from Unit B

and the top of bedrock aquifer (shallow bedrock wells) indicate that residual materials may be contained in the unsaturated portion of the weathered bedrock but are limited to a small area on the northern-central portion of the site, around ECC-MW-30B, EE-MW-41S, and the former sump of the Process Building. Although the sump was built to accept wastewater from the building, it may have been used as a disposal point for other wastes.

Concentration trends for CT and TCE in other site bedrock wells are relatively stable. The concentrations of VOCs detected in Units C and D at the same location of Unit B are lower as a result of minor downward vertical leakage through fractures.

There is no evidence of site activities that would be associated with 1,4-dioxane or PFAS. The site was previously sampled for 1,4-dioxance however and no samples exceeded the detection limits.

2.5.3.2 Summary of Radionuclides in Groundwater

Concentrations of groundwater samples evaluated for the primary radionuclide of concern, uranium, suggests that the Soils OU1 remedial action has greatly improved the MSP site's groundwater quality for radionuclides. Prior to the Soils OU1 remedial action, uranium concentrations exceeded the MCL criteria of 30 micrograms per liter (µg/L) by a factor of 10. Several wells exhibited elevated concentrations since that remedy was completed (MW-OB-7, MW-OB-8, MW-OB-10, and MW-OB-12), with results marginally above criteria, and only MW-OB-7 and MW-OB-10 had an exceedance in 2012. Both MW-OB-7 (as shown on Figure 2-2, south of the former Process Building) and MW-OB-10 (as shown on Figure 2-2, north of the former Process Building) contained concentrations of uranium above the MCL in more than one sampling event. Overburden wells MW-OB-7 and MW-OB-10 were abandoned because the filter packs were saturated with silt, and the presence of silt in samples is thought to be the cause of exceedances in both wells. MW-OB-7 was replaced in August 2014 with MW-OB-7R within 10 feet of the original location. Well MW-OB-7R was sampled in October 2014 and November 2015. MW-OB-10 was not replaced as adjacent wells MW-OB-12 and MW-OB-13 provide sufficient monitoring. No exceedances were detected in the most recent sampling events in 2014 and 2015.

2.6 Current and Potential Future Site and Resource Uses

Site topography is relatively flat with surface elevations ranging from approximately 58 feet above mean sea level at the north end to 49 feet above mean sea level along the south end. Storm water flows over the site surface as sheet flow to the south and is collected and discharged off site into the South Drainage Ditch. The property to the south consists of a marshy land and fields. South Drainage Ditch carries surface water runoff from the site into Main Stream and is approximately 1,150 feet long. The Main Stream flows intermittently in a southwesterly direction for approximately 2,100 feet where it flows through wetlands (Palustrine Forested and Palustrine Scrub/Shrub) prior to discharging into Ambrose Brook. Fractured shale, siltstone, and sandstone bedrock underly the site and are referred to as the Passaic Formation. Groundwater contained within the fractures of this bedrock makes up the aquifer (Brunswick Aquifer) and is the major aquifer of the region located throughout a large part of central and northeastern New Jersey. It is used for domestic, municipal, and industrial water supplies in Middlesex and surrounding counties.

In 2010, the USACE conducted a private potable water well survey to determine the number of registered wells within 0.50 miles of the MSP. The USACE used several resources to identify and locate supply wells that may still be in service for providing potable water to residents or local businesses. The on-line NJDEP well search resource was used to identify registered wells within a half-mile of the MSP, which resulted in the identification of 12 properties with records of existing potable water wells. To investigate additional properties within the search area that may exist, but are not registered with the state, the USACE consulted with the Middlesex Department of Health (DOH) to request a list of properties with a water well or a record of identified contamination. The DOH did not identify any wells that had not been already identified through the NJDEP search.

In order to provide a more comprehensive assessment, Middlesex, New Jersey tax maps were searched to identify addresses within a 0.50-mile radius of the MSP that could potentially be impacted by contamination from the MSP. Over 300 properties were identified. After crosschecking the address list with the New Jersey-American Water Company to eliminate properties on public water supply, 42 properties could not be verified as supplied by a public water source and, therefore, potentially relying on groundwater obtained from a potable well. A field reconnaissance, which included door-to-door inquiries or roadside identification of public supply well taps, was completed for each property.

The document search and field reconnaissance resulted in a list of eight properties (in addition to one previously identified on Mountain Avenue) that were potential candidates for utilizing a private potable well for drinking water (USACE 2017b). Groundwater samples were collected from seven of the eight properties. VOC detections were below the NJDEP drinking water criteria in seven of the wells. USACE made several attempts to contact the homeowner at the eighth property via mail, phone, and visits by the Project Manager, but was unable to establish contact, so it could not be sampled. One additional groundwater sample was collected from the potable water well located on Mountain Avenue, adjacent to the MSP. The analytical test results for that well indicated VOC concentrations above the NJDEP drinking water criteria; therefore, a temporary carbon filter treatment system was installed until the residence could be connected to the public water supply. The carbon filter treatment system was removed when the residence was connected to a public water supply in 2011.

2.7 Summary of Site Risks Posed by Groundwater

Two HHRAs were conducted for the MSP site groundwater to determine the current and future cancer risks and non-cancer hazards from exposure to COCs in groundwater. A Baseline HHRA was developed in 2005 as part of the Groundwater OU2 RI (USACE 2005b) and a Supplemental HHRA was completed following the collection of additional groundwater data collected during the 2014 through 2016 investigations (USACE 2017a). The Baseline HHRA evaluated the cancer risks and non-cancer health hazards from site contaminants (e.g., radionuclides, VOCs, SVOCs, and metals) in on-site groundwater to possible future residential receptors at the site in the absence of institutional controls (e.g., CEA/WRA or other restriction on groundwater use), and the risks from surface water and sediment to recreational receptors (trespassers). Based on the findings presented in the groundwater investigation reports and the results of the risk assessments completed for the MSP, no unacceptable risks were identified for the child recreator/trespasser via ingestion of and dermal contact with impacted sediment and surface water; therefore, these media did not warrant further evaluation. The Supplemental HHRA for the MSP site evaluated the risks

associated with VOCs in groundwater to possible future on-site workers and possible future off-site residential receptors. Groundwater sample results for the two most recent sampling events (2014 and 2015) from five wells within the core of the plume were used for the Supplemental HHRA. Both HHRAs evaluated possible future exposure pathways. Groundwater at the site is not currently used, and there are no current plans for its use in the future.

A SLERA performed in 2005 concluded that ecological impacts from contaminants in surface water and sediment were unlikely (USACE 2005b). Further, no sensitive habitat was identified on site, and it was determined that current and potential future land uses on site made it unlikely that the area would be a significant ecological habitat. The MSP is currently undeveloped, vacant land covered with grass and zoned for industrial use by the Borough of Middlesex Planning Commission.

An additional SLERA was completed in 2016, documented in the *Groundwater Investigation Technical Memorandum* (USACE 2017b), and evaluated the potential for harmful effects to ecological receptors exposed to chemicals and radionuclides released from the facility to surface water and sediments. Maximum concentrations of metals, organic compounds, and radionuclides were used to assess potential risk to these receptors. Results indicated that site-related VOCs are migrating off-site via bedrock bedding planes that do not discharge into surface water systems and there is no pathway to ecological receptors (USACE 2017b). In addition, no ecological habitats have been identified at the MSP site. For full details regarding risk assessment, refer to the 2005 Groundwater Operable Unit Remedial Investigation Report, Middlesex Sampling Plant and the 2017 Final Feasibility Study Report Groundwater Operable Unit 2, Middlesex Sampling Plant FUSRAP Site.

2.7.1 Human Health Risk Assessments

Current USEPA guidelines for acceptable exposures are based on a Reasonably Maximally Exposed individual – resulting in a lifetime excess cancer risk in the range of 1×10^{-4} to 1×10^{-6} (corresponding to a 1 in 10,000 to 1 in 1,000,000 increase in the probability of cancer).

For non-cancer health effects, a "hazard index" (HI) is calculated. An HI represents the sum of the individual chemical hazard quotients. The HI may be further evaluated to derive HIs based only on chemicals which impact the same target organ systems. The key concept for a non-cancer HI is that a "threshold level" (measured as an HI of 1) exists below which non-cancer health effects are not expected to occur.

Though there are no known plans to use the groundwater in this area in the future, use of this aquifer for a water source still presents a potential future risk. The primary designated use for groundwater in the area is as potable groundwater with conventional treatment at current water quality (Class II-A). Therefore, the risk assessment assumed the best use of groundwater to be potable while determining exposure scenarios. Contaminated groundwater emanating from the site migrates beneath residential (off-site) and commercial/industrial properties (on-site and off-site) and, therefore, both exposure scenarios were evaluated in the risk assessment.

2.7.1.1 Baseline Human Health Risk Assessment

The Baseline HHRA performed in 2005 evaluated the risks from contaminants (radionuclides, VOCs, SVOCs, and metals) in on-site groundwater to possible future residential receptors at the site. The chemicals of potential concern that were carried through the Baseline HHRA process included nine radionuclides, six VOCs, two SVOCs, and 13 metals. It should be noted that this Baseline HHRA was performed prior to the soil removal included as part of the Soils OU1 remedial action and concentrations of uranium in groundwater have decreased significantly since this action.

2.7.1.1.1 Results of the Baseline HHRA

The following is a summary of the results of the Baseline HHRA:

- The potential cancer risk associated with groundwater use by a possible future on-site resident was approximately 1 x 10^{-4} for a sitewide average concentration, which is equal to the upper limit of USEPA's acceptable risk range. Uranium contributed 7 x 10^{-5} of the risk and radium contributed 2 x 10^{-5} of the risk. Chemical exposure from VOCs comprised 2 x 10^{-5} of the risk. The maximum cancer risk at any well due to radiological contamination was in well B18W-24S (6 X10-4) primarily due to ingestion of uranium in drinking water.
- Hazard indices exceeded 1 for the resident (HI of 5) and child resident (HI of 14) for average sitewide groundwater exposure. The exceedance of the noncancer benchmark was primarily based on the concentration of manganese. For the well with the highest radiological contamination (B18W24S), the HI for the child resident was 15 due to the uptake of uranium. For the well with the highest chemical risk (URSMW2D), the HI for the child resident was 6, primarily due to CT concentrations.
- Exposure to sediments and surface water at the MSP posed a cancer risk of 2 x 10^{-5}, which is within USEPA's acceptable risk range. Non-cancer health effects from sediments and surface water are unlikely.

The following contaminants were identified as COCs in the Baseline HHRA: total uranium (as a toxic metal); uranium-238 and uranium-234 (as radiological contaminants); CT; and manganese. Since completion of the Baseline HHRA in 2005, the soil removal included as part of the Soils OU1 remedial action (completed in 2008) has been performed and the concentrations of uranium in groundwater have decreased significantly. Concentrations of uranium in groundwater have not been observed above the USEPA MCL for drinking water since 2012, during Sampling Event 13 (Table 2-1). However, because uranium is associated with past site operations, and had been present in site groundwater at concentrations above regulatory cleanup levels, it has been retained as a COC (see Section 2.5.2.6). Uranium exceeded potential cancer risk levels during the 2005 Baseline Human Health Risk Assessment. Although an additional risk assessment has not been conducted at the site, uranium concentrations have reduced since then to concentrations below the USEPA MCL for uranium. There was no evidence that manganese had been used for government activities and it was determined to be part of the natural background at the site (Serfes 1994). Therefore, manganese was not retained as a COC.

2.7.1.2 Supplemental Human Health Risk Assessment

The Supplemental HHRA for the MSP site evaluated the risks associated with VOCs in groundwater to possible future on-site workers and possible future off-site residential receptors (USACE 2017b). Groundwater sample results for the two most recent sampling events (2014 and 2015) from five wells within the core of the plume were used for the risk assessment. Potential receptors included: hypothetical future workers (with potential exposure through the ingestion of groundwater while at work) and residents (adults and children, with potential exposure through the ingestion of groundwater, dermal contact during bathing/showering, and inhalation of vapors while showering). Based on the potential risks and hazards identified by the Supplemental HHRA, CT, TCE, and chloroform were identified as COCs (i.e., significantly contributing to unacceptable risk and/or hazard).

2.7.1.2.1 Results of the Supplemental HHRA

The results of the Supplemental HHRA are summarized below and in Table 2-3:

- For the adult worker exposure to groundwater, the reasonable maximum exposure (RME) cancer risk exceeded USEPA's acceptable risk range. The total cancer risk of 1.4×10^{-3} was primarily due to CT.
- The central tendency exposure (CTE) cancer risk was within the acceptable risk range at 9.0×10^{-5}. The HI for the adult worker exposure to groundwater was 17.3 for the RME scenario primarily due to CT and TCE. The HI for the CTE scenario was 4.2, primarily due to CT.
- For the child residential exposure to groundwater, the RME cancer risk exceeded USEPA's acceptable risk range. The total cancer risk of 1.2×10^{-3} was primarily due to CT. The CTE cancer risk also exceeded the acceptable risk range at 2.5×10^{-4}. The HI for the child resident exposure to groundwater was 59.1 for the RME scenario primarily due to CT, chloroform, and TCE. The HI for the CTE scenario was 17.9 due to CT and TCE.
- For the adult residential exposure to groundwater, the RME cancer risk exceeded USEPA's acceptable risk range. The total cancer risk of 3.4×10^{-3} was primarily due to CT and chloroform. The CTE cancer risk also exceeded the acceptable risk range at 4.6×10^{-4}. The HI for the adult resident exposure to groundwater was 48.6 for the RME scenario primarily due to CT, chloroform, and TCE. The HI for the CTE scenario was 15.9 due to CT and TCE.

Site-Related Evaluation. Low level concentrations of methyl tert-butyl ether (MTBE), cis-1,2-dichloroethylene, 1,1-dichloroethane, and 1,1-dichloroethene were detected in both the upgradient well and the core of the plume wells indicating a potential off-site source. These analytes did not, however, contribute to excess risk or non-cancer hazards at the MSP site. USACE will address VOC contamination in consideration of future redevelopment of the site and potential future use of impacted groundwater on the property.

Vapor Intrusion. VOCs present in unsaturated soil or in the dissolved phase in groundwater can act as a source for contaminant vapors that have the potential to migrate into indoor air. For a health risk to exist, a source, a receptor, and a pathway must be present. Vapors migrating upward can accumulate beneath relatively impermeable structures such as buildings and potentially migrate into buildings, posing a potential health risk.

Potential sources for vapor intrusion at the site may include contaminated soils and groundwater. VOCs were not detected in soils during the OU1 RI in sufficient concentrations or frequency to consider them site COCs (USACE 2004). In addition, unsaturated site soils were removed during the OU1 remedial excavation in 2008 and backfilled using clean fill (USACE 2010b). Therefore, there is no source of VOCs in site unsaturated soils on the MSP property that could produce vapors, and this potential pathway does not exist currently or in the future on this site. VOCs were not detected in the saturated overburden unit at concentrations greater than USEPA Vapor Intrusion Screening Levels or NJDEP Generic Vapor Intrusion Screening Levels for groundwater in the saturated overburden unit (USEPA 2016a; NJDEP 2013). VOCs were detected in the bedrock aquifer at concentrations above both federal and state groundwater screening levels for vapor intrusion.

Although a groundwater source and existing and potential future receptors are present, the saturated overburden unit provides a barrier above the contaminated groundwater that blocks potential upward vapor migration. Therefore, no pathway for vapor intrusion into indoor air from soils and groundwater exists at the site. These data indicate a reduced potential for human health risks from exposure to vapors.

HHRA Results. Based on the calculated cancer risks and non-cancer hazards described above, CT, chloroform, and TCE were identified as COCs in the Supplemental HHRA.

2.7.2 Screening-Level Ecological Risk Assessment (SLERA)

A SLERA was conducted for the MSP groundwater in 2005 for the site contaminants identified at that time (USACE 2005b). This SLERA, which was completed as part of the OU2 Groundwater RI, evaluated the potential for harmful effects to ecological receptors exposed to chemicals and radionuclides released from the facility to surface water and sediments. Maximum concentrations of metals, organic compounds, and radionuclides were used to assess potential risk to these receptors.

2.7.2.1 Results of the SLERA

The following is a summary of the results of the SLERA:

- Historic water and sediment sampling demonstrate that site-related concentrations decrease with distance from the MSP. Sediment and surface water samples collected to support this SLERA were collected from the drainageway leading from the MSP outfall to the Main Stream at Cedar Avenue (near the confluence with Ambrose Brook). Concentrations at the Cedar Avenue monitoring location in water and sediments were found to be within background levels. Limited sampling of Ambrose Brook sediments has been conducted during past investigations at the MSP site. Results have been within the typical range of background concentrations. The most significant sampling effort of Ambrose Brook was when the USDOE conducted an investigation of the nearest sediment accumulation point of Ambrose Brook in Willow Lake (now known as Lake Creighton). The investigation concluded that the lake sediments were within typical background levels for MSP contaminants (USACE 2017a).
- A number of metals were present in surface water at maximum detected concentrations above background levels and Ecological Screening Values (ESVs). However, ecological impacts

from these constituents in surface water are unlikely since the average concentrations of these metals were below their respective ESVs.

- A single organic detection in surface water (benzo[a]anthracene) was below the practical quantitation limit, but above the ESV. Based on the limited extent of detected contamination, ecological impacts from this contaminant are unlikely.
- Radionuclide doses were projected for aquatic and benthic organisms, taking into account external and internal exposure routes. The total doses projected for these receptors were less than 0.1 rad per day, the ESV adopted for the SLERA. On the basis of these calculations, no radionuclides were identified as COCs.
- Concentrations of metals in the sediments are similar to the distribution in the background samples. Maximum detections of some metals were above the ESV and background levels. Cadmium, copper, lead, manganese, and zinc each have mean concentrations greater than background, with the average concentration of each contaminant no more than 2.5 times its respective background. Ecological impacts from contaminated sediments are unlikely.
- Sensitive habitat has not been identified on site, and the current and likely future land uses make it unlikely that this area would be a significant ecological habitat.

Additional information on VOCs collected during the supplemental groundwater sampling and documented in the Groundwater Investigation Technical Memorandum indicated that site-related VOCs are migrating off-site via bedrock bedding planes that do not discharge into surface water systems and there is no pathway to ecological receptors (USACE 2017b). In addition, no ecological habitats have been identified at the MSP site.

2.8 Remedial Action Objectives

Based on the results of the RI/FS and the risk assessments, USACE and USEPA have determined that the response action selected in this ROD is necessary to protect the public health, welfare and the environment from actual or threatened releases of hazardous substances into the environment. As required by the NCP, site-specific remedial action objectives (RAOs) were established that take into account the nature and extent of contamination, resources that are currently and potentially threatened, and potential for human and environmental exposure (USEPA 1990).

The RAOs are based on mitigating human exposure to COCs in groundwater that exceed the cleanup levels for the contaminated site groundwater. These exposures may occur by ingestion of groundwater; and indoor use of groundwater, such as showering, cooking, and washing clothes or dishes. The RAOs established for the site are:

- To prevent current and future exposure of human receptors (via ingestion, dermal contact, and inhalation) to site related contaminants in groundwater that exceed cleanup levels; and,
- To return groundwater to its most beneficial use as a source of drinking water.

2.8.1 ARARs

Remedial actions must remediate contamination at CERCLA sites to levels set by ARARs, if there are any. ARARs are substantive cleanup standards, standards of control, or other requirements that

relate to the contamination, the remedial action, or the remedial location found in federal environmental and more stringent state environmental and facility siting laws that are applicable or relevant and appropriate to the site and remedial action. There are three types of ARARs: chemical-specific, location-specific, and action-specific.

There are no location-specific ARARs associated with the MSP site. Chemical-specific ARARs for the MSP site include the federal MCLs and NJGWQS. In the case of differing standards or criteria, the more stringent criterion will be selected as the ARAR.

For action-specific ARARs, only the requirements for Underground Injection Control (authorized under the Safe Drinking Water Act) apply to the MSP. This ARAR regulates injection of fluids, including air, into the groundwater, and only applies to groundwater treatment alternatives at the MSP.

Table 2-4 lists the chemical-specific cleanup levels that have been identified for the groundwater remedial action.

2.8.2 Identification of FUSRAP Groundwater COCs

In order to identify the contaminants posing unacceptable risks or exceeding cleanup levels within the groundwater, a characterization program and HHRAs were performed as described in Section 2.7. Unacceptable risks were identified for contaminants only in the groundwater media of OU2. No unacceptable risks were identified for chemicals detected in the surface water or sediment. Contaminants identified in groundwater as COCs on the basis of potential risks to future residents (off-site) and/or on-site workers are:

- Total uranium (as a toxic metal);
- Uranium-238 and uranium-234 (as radiological contaminants);
- CT;
- TCE; and
- Chloroform.

The more stringent of the promulgated values described in Section 2.8.1 for each COC identified for the MSP has been selected as the chemical-specific ARAR or cleanup level (Table 2-4). The uranium MCL of 30 µg/L is protective of kidney toxicity and cancer risk associated with U-234 and U-238 radioactivity (USEPA 2000). Therefore, separate cleanup levels were not established for the uranium isotopes. The cleanup levels for the VOCs were based on the NJGWQS, including 1.0 µg/L for trichloroethene and 70 µg/L for chloroform. The cleanup level selected for CT at this site was 1.0 µg/L (the reporting limit censored at the practical quantitation limit), despite the fact that the NJGWQS is 0.4 µg/L, because 0.4 µg/L is below the reporting limit (i.e., the lowest concentration that can be reported with a reasonable degree of accuracy and precision).

2.9 Description of Alternatives

The focus of the remedial action alternatives was to meet the cleanup levels associated with residual low-level radionuclides (uranium) in the overburden groundwater unit and VOCs in the underlying unsaturated bedrock and bedrock aquifer, primarily Unit B.

Four alternatives were evaluated for the MSP Groundwater OU2:

- Alternative 1: No Action (30-year estimated cost: $0);
- Alternative 2: MNA and LUCs (30-year estimated cost: $2,711,000);
- Alternative 3: Treatment with ISCR, MNA, and LUCs (30-year estimated cost: $7,833,000); and,
- Alternative 4: Pump and Treat, MNA, and LUCs (30-year estimated cost: $11,951,000).

The development of these alternatives considered the fact that the on-site contaminated soil was removed and backfilled with clean soil during the OU1 remedial action. The replacement of contaminated soil with clean soil resulted in significant reduction of uranium concentrations in the overburden groundwater. However, it was assumed that residual levels of uranium contamination in groundwater could remain and would need to be addressed by a remedial action. The alternatives also addressed VOC contamination attributable to past site activities.

2.9.1 Alternative 1: No Action

The No Action alternative is considered in accordance with the NCP [40 Code of Federal Regulations (CFR) 300.430(e)(6)] and is intended to provide a baseline comparison to the other alternatives. In this alternative, no remedial systems would be installed or operated, and no LUCs, such as a CEA/WRA, would be used for groundwater. Improvement of the groundwater quality would be through natural attenuation including dispersion, adsorption, and dilution. Groundwater monitoring would not be conducted; therefore, improvement or further degradation of water quality would not be documented. No costs are associated with this alternative, since there would be no action taken. The time frame for Alternative 1 would be indefinite, cleanup levels will not be achieved within 30 years.

2.9.2 Alternative 2: Monitored Natural Attenuation and Land Use Controls

Alternative 2 relies upon monitoring of the groundwater contaminant plume to determine whether contamination is being reduced by natural environmental processes as defined in USEPA Office of Solid Waste and Emergency Response Directive 9200.4-17P, *Use of Monitored Natural Attenuation at Superfund, Resource Conservation and Recovery Act Corrective Action and Underground Storage Tank Sites*, dated April 21, 1999. MNA processes applicable to the MSP site include dispersion, dilution, and adsorption. All of these processes are applicable to TCE and CT and help reduce contaminant concentrations over time. Natural attenuation processes, such as dispersion, dilution, and adsorption, apply to TCE and CT while dispersion and adsorption are applicable to total uranium. MNA relies on monitoring to determine whether contaminants are spreading beyond current boundaries at concentrations exceeding cleanup levels. The ultimate duration of the groundwater monitoring program would be based on the sample results that demonstrate whether the impacted groundwater has contaminant concentrations that meet the

cleanup levels. Under this alternative, it is expected that contaminant concentrations will continue to decrease over time as a result of the source removal completed during the Soils OU1 remedial action in 2008 and natural attenuation. Dispersion processes would be especially effective in diminishing contaminant plumes of limited extent and relatively low concentrations. The decreasing trends or the presence of daughter products (e.g., chloroform, DCE) will be noted as evidence of natural attenuation.

An integral part of this alternative is the implementation of a groundwater monitoring program, which would be conducted within and immediately adjacent to the perimeter of the site to assess potential contaminant migration and whether cleanup levels are met. A long-term monitoring program, consisting of existing monitoring wells and new monitoring wells installed in Year 1 of implementation, would be developed and the progress of MNA would be documented in reports for each monitoring event. The exact number of wells, design of the well network, and type of parameter analyses to be performed would be determined during the remedial design process. The duration of the groundwater-monitoring program would be based on attainment of the cleanup levels. Water quality results and review of location and number of monitoring wells would be provided in an annual monitoring report. Implementation of the remedial alternative would be considered complete when the concentrations of the COCs at each monitoring well no longer exceed their cleanup levels for three consecutive sampling rounds.

Under this alternative, LUCs would be implemented, such as well restrictions in a CEA/ WRA or deed restriction (if not on federally owned property, the landowner's concurrence would be required). However, well restrictions in a groundwater CEA/WRA are preferable over deed restrictions since the federal government does not own all of the affected property and establishment of a groundwater CEA/WRA is sufficient. NJ law requires the NJDEP to establish a CEA/WRA in the affected areas associated with the MSP site when USACE submits the information listed in New Jersey Administrative Code (NJAC) 7:26E-8.3 to assist the NJDEP in establishing the CEA/WRA. The CEA/WRA would remain in effect until the concentrations of VOCs in the area identified as subject to the CEA/WRA aquifer are below the cleanup levels.

The estimated time for Alternative 2 to achieve cleanup levels is greater than 30 years. The remedial action would need to be reviewed at least once every five years, as long as contaminants remain above cleanup levels that allow for unlimited use and unrestricted exposure. The capital cost for this alternative was estimated at $1,233,000 and the annual operation and maintenance cost was estimated at $149,000. The 30-year present worth cost for this alternative was estimated to be $2,711,000.

2.9.3 Alternative 3: Treatment with In-situ Chemical Reduction, Monitored Natural Attenuation, and Land Use Controls

Alternative 3 is a combination of remedial technologies to treat the various contaminants present in groundwater at the site. ISCR technologies will treat the VOCs present in groundwater situated in the fractured bedrock within Unit B on site at the source area. This treatment would eventually eliminate VOCs emanating from the site source area, thereby reducing the long-term chlorinated VOCs mass flux from the source area feeding the off-site portion of the plume and isolate groundwater with low concentration VOCs in the downgradient portion of the plume. MNA would address the on-site VOCs not influenced by active treatment, the downgradient portion of the VOC

plume, and any residual uranium present in the overburden groundwater. A LUC in the form of a groundwater CEA/WRA would be utilized in areas of groundwater contamination present at the site until cleanup levels are achieved. CERCLA Five-Year Reviews would be required at least once every five years, as long as contaminants remain above cleanup levels that allow for unlimited use and unrestricted exposure.

ISCR applications are anticipated to degrade site COCs with contact and enhance mass reduction. ISCR is typically applied by injecting chemically reductive additives in liquid form into the source area and the areas of elevated VOC concentrations. The ISCR injection point/well locations are included on Figure 2-8. The ISCR reagent ultimately facilitates the breaking of chemical bonds, eventually transforming groundwater contaminants into less harmful chemical species. The type and physical form of the reduction reagent indicates the general materials-handling and injection requirements. The persistence of the reagent in the subsurface is important since this affects the contact time for advective and diffusive transport and ultimately the delivery of reagent to targeted zones within the groundwater contaminant plume. The selected reduction reagent would reduce groundwater contaminants to the maximum extent technically practical, at which time a transition to MNA would occur until cleanup levels are attained.

ISCR would be applied to remediate contamination in the on-site source area. Additional site data would be collected during the remedial design phase to determine the numbers of injection events and injection points and the depths of the injection wells. Most sites require multiple injections due to preferential treatment zones, the release of organically partitioned contamination, desorption from soil media, and non-aqueous phase liquid dissolution.

ISCR injection would not target off-site wells with elevated concentrations farther from the source (e.g., EE-MW-37B which is 1,000 feet northwest of the on-site source). Contaminant concentrations are lower at these locations, and the locations are spread over a much larger area, which would require multiple rounds of injection. In addition, the contamination is located beneath a densely populated area, which would present significant access difficulties. The wells at these locations would be included as part of the long-term monitoring program. Additional injections may be needed from a remedy optimization perspective if adequate progress towards the RAOs is not being made based on the results of any future CERCLA Five-Year Reviews.

The amount of VOC reduction would be assessed by comparing results of pre-injection (baseline) and post-injection groundwater samples. Additional injections would be made until the post-injection sampling indicates that further injections are not needed or would not be helpful. For estimating purposes, it has been assumed that active remediation will achieve cleanup levels in the source area in approximately 10 years. However, a total treatment timeframe of 30 years is estimated for MNA to address the on-site VOCs not influenced by active treatment, the downgradient portion of the VOC plume, and any residual uranium present in the overburden groundwater. The implementation of the remedial alternative would be considered complete when the concentrations of COCs at each individual well do not exceed their cleanup values for three consecutive sampling rounds. The CEA/WRA would remain in effect until the concentrations of VOCs in the area identified as subject to the CEA/WRA aquifer are below the cleanup levels. CERCLA Five-Year Reviews will also be required as long as contaminants remain above cleanup levels that allow for unlimited use and unrestricted exposure. Additional information associated with the assumptions used to develop costs for this alternative are presented in the *Final Feasibility*

Study Report, Groundwater OU2 (USACE 2017a). The capital cost for this alternative is approximately $5,471,000 and the annual O&M cost was estimated to be $162,000. The 30-year present worth was estimated to be $7,833,000.

2.9.4 Alternative 4: Pump and Treat, Monitored Natural Attenuation, and Land Use Controls

Alternative 4 is a combination of remedial technologies to treat the various contaminants present in groundwater at the site. Removal of contaminated groundwater by pumping is expected to address the VOCs (TCE, CT, and chloroform) present in groundwater situated in the fractured bedrock on site. Extraction wells would be placed in the source area and along the downgradient property boundary to control and eventually eliminate VOCs emanating from the source area. This would effectively isolate low concentration areas of the plume observed in deeper wells beneath the site and downgradient of the site. MNA processes would reduce these low concentration areas of the VOC plume outside of the active treatment area and any residual uranium present in the overburden groundwater. A LUC in the form of a groundwater CEA/WRA would be utilized in areas of groundwater contamination present at the site until cleanup levels are achieved. The remedial action would need to be reviewed at least once every five years, as long as contaminants remain above cleanup levels that allow for unlimited use and unrestricted exposure.

Pump and treat would involve the use of a conventional pump-and-treat system technology. Extraction wells would be placed strategically in the areas of higher concentrations to target contaminant removal and placed in downgradient areas to prevent further migration of the plume. Construction of the pump and treat system would be initiated by installing approximately five groundwater extraction wells to a depth of 30 feet (in Unit B) in the source area and areas of elevated VOC concentrations to recover as much of the mass as possible in the first 15 years of operations, after which they could then be converted to low flowrate extraction wells with pneumatic pumps for the remaining operational period. In addition, eight wells will be installed in a line along and inside the downgradient property boundary for migration control to a depth of 70 feet (in Unit B), as low flowrate extraction wells pumping at approximately 1 gallon per minute, because of the low transmissivity of the aquifer units. Many installation methods can be used to install the extraction wells. Based on the bedrock present at the site, air or mud rotary drilling techniques would be anticipated.

For the purposes of costing this alternative, the specific well design and numbers of wells were assumed based on the size of the plume and assumed aquifer characteristics. Due to the presence of VOCs in fractured bedrock where transmissivities are low, groundwater extraction rates would be limited, thus creating a relatively small capture zone and requiring dense well spacing. For reasons described in Alternative 3, this alternative will not target off-site wells.

Based on the sampling results, it is assumed that extracted groundwater would exhibit levels of contamination that exceed local discharge permit levels. Therefore, extracted groundwater would be pumped to a treatment system, and the treated effluent would be tested and discharged to a publicly owned treatment works.

The treatment system proposed for this alternative would consist of a multi-stage operation involving two distinct processes. While both air stripping and granular activated carbon (GAC) could be used individually to achieve the desired effluent requirements, for the development of this alternative, air stripping followed by GAC treatment would be used. In the event that either

process experiences an equipment malfunction, a backup system would reduce the potential for exceeding the effluent limitations.

Pilot testing in the remedial design phase may be necessary to ensure the optimal process and actual design for treatment, where contact time and actual flow capacities would be determined. The treatment system would be designed for the anticipated flow rate of extracted groundwater and would be presented in the remedial design.

Pump-and-treat systems are widely used to remediate groundwater and are, therefore, relatively straightforward to design, construct, and operate. If the extraction system and treatment equipment is appropriately sized, cleanup levels established for site groundwater and discharge effluent would be met. During the remedial design, groundwater modeling and mass balance calculations would need to be performed to determine the appropriate well locations, extraction rates, equipment size, and operation and maintenance needs.

Once groundwater monitoring indicates that contaminant concentrations consistently meet the cleanup objectives, the pump-and-treat system would be shut down, and the groundwater table would be allowed to equilibrate back to pre-remedial effort levels. The implementation of the remedial alternative would be considered complete when the concentrations of COCs at each individual well do not exceed their cleanup values for three consecutive sampling rounds after system shutdown. For cost estimating purposes, it has been assumed that the treatment system would be in operation for at least 30 years to achieve the site cleanup levels. The downgradient VOC plume would also be monitored for a total of 30 years, with CERCLA Five-Year Reviews conducted every five years as long as contaminants remain above cleanup levels that allow for unlimited use and unrestricted exposure. The CEA/WRA would remain in effect until the concentrations of VOCs in the area identified as subject to the CEA/WRA aquifer are below the cleanup levels.

Uranium concentrations in groundwater are already below cleanup levels and are expected to decrease since the source has been removed but would be monitored as part of the MNA program. The capital cost for this alternative is approximately $3,039,000 and the annual operation and maintenance cost was estimated to be $608,000. The 30-year present worth was estimated to be $11,951,000.

2.10 Expected Outcomes of Each Alternative

Alternative 1 would not achieve cleanup levels and, thus, is unacceptable. In contrast, the expected outcome for Alternatives 2, 3, and 4 would be the attainment of the RAOs and the ability to eventually release the property for beneficial reuse.

2.11 Comparative Analysis of Alternatives

Remedial alternatives are assessed on the basis of both a detailed and a comparative analysis pursuant to the NCP. The analysis of MSP consisted of (1) an assessment of the individual alternatives against nine evaluation criteria established by the NCP [40 CFR 300.430(e)(9)(iii)] and (2) a comparative analysis focusing upon the relative performance of each alternative against the criteria.

In general, the following "threshold" criteria must be satisfied by an alternative for it to be eligible for selection:

1. Overall protection of human health and the environment addresses whether a remedy provides protection and describes how risks posed through each exposure pathway (based on an RME scenario) are eliminated, reduced, or controlled through treatment, engineering controls, or remedial action with remedy performance monitoring.
2. Compliance with ARARs addresses whether a remedy would (a) meet all of the ARARs, or (b) provide grounds for invoking a waiver.

In addition, the following "primary balancing" and "modifying" criteria are used to make comparisons and identify the major trade-offs among alternatives:

3. Long-term effectiveness and permanence refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup levels have been met. It also addresses the magnitude and the effectiveness of the measures that may be required to manage the risk posed by treatment residuals and/or untreated wastes.
4. Reduction of toxicity, mobility, or volume via treatment refers to a remedial technology's expected ability to reduce the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants at the site through treatment.
5. Short-term effectiveness addresses (a) the period of time needed to achieve protection and (b) any adverse impacts on human health and the environment that may be posed during the construction and implementation periods until cleanup levels are achieved.
6. Implementability refers to the technical and administrative feasibility of a remedy, including the availability of materials and services needed.
7. Cost includes estimated capital, operation and maintenance, and present-worth costs.
8. State acceptance indicates whether, based on its review of the RI, FS and the proposed plan, the state supports or opposes any of the alternatives and/or has identified any reservations with respect to any of the alternatives.
9. Community acceptance refers to the public's general response to the alternatives described in the proposed plan and the RI and FS reports. Factors of community acceptance include support, reservation, or opposition by the community.

A comparative analysis of the four alternatives based on the nine evaluation criteria is presented in Sections 2.11.1 through 2.11.10, and is also included in Table 2-5. A complete comparative analysis was provided in the OU2 Groundwater FS.

2.11.1 Criterion 1: Overall Protection of Human Health and the Environment

Alternative 1 does not provide protection of human health and the environment in the short or long term because it does not reduce risk or exposure from COCs in the groundwater. It also allows for the continued existence of exposure pathways and does not implement any LUCs.

Alternatives 2, 3, and 4 would be considered protective of human health. Although no active remedial treatment measures would occur under Alternative 2, protection in the short-term could still be achieved through implementation of LUCs. Also, a groundwater-monitoring program would assess the progress and rate of natural degradation towards achieving cleanup levels. Alternatives 3 and 4 would protect human health and the environment by combining active remediation with the implementation of LUCs and an MNA program, which would assess the attainment of cleanup levels.

Alternative 2 would be slower (greater than 30 years, possibly an indefinite timeframe) compared to Alternatives 3 (10 years of active treatment in the source area, with a total of approximately 30 years of MNA in the untreated areas) and Alternative 4 (at least 30 years of active treatment and MNA).

2.11.2 Criterion 2: Compliance with ARARs

Under Alternative 1, no action is taken so changes in concentrations of groundwater COCs would not be documented, and LUCs would not be in place to restrict access to impacted groundwater. Alternative 2 would eventually result in COC concentrations below the chemical-specific cleanup levels identified in Table 2-4 through natural environmental processes. LUCs would restrict access to impacted groundwater until the cleanup levels are achieved. Alternative 2 may take longer than 30 years to achieve cleanup levels (i.e., indefinite timeframe), with CERCLA Five-Year Reviews required every five years as long as contaminants remain above cleanup levels that allow for unlimited use and unrestricted exposure.

Alternative 3 is expected to accelerate the timeframe required to meet the chemical-specific cleanup levels. The FS estimated that active remediation would achieve cleanup levels in the source area in approximately 10 years. However, a total treatment timeframe of 30 years was estimated for MNA to address the on-site VOCs not influenced by active treatment, the downgradient portion of the VOC plume, and any residual uranium present in the overburden groundwater. CERCLA Five-Year Reviews will also be required every five years, as long as contaminants remain above cleanup levels that allow for unlimited use and unrestricted exposure. Substantive requirements applicable to Underground Injection Control, under the Safe Drinking Water Act, are action-specific ARARs for Alternative 3, and would be met during implementation.

Alternative 4 would result in COC concentrations below the chemical-specific cleanup levels through the implementation of a pump-and-treat technology in the source area and MNA in untreated areas. The ground water pump-and-treat system would be in operation for at least 30 years. MNA would address the low concentration areas of the VOC plume outside of the active treatment area and any residual uranium present in the overburden groundwater in that same timeframe. Alternatives 2, 3, and 4 would include a monitoring program to determine when groundwater cleanup levels are achieved for both the saturated overburden unit and bedrock aquifer.

Alternatives 3 and 4 would also implement LUCs to restrict access to impacted groundwater until the cleanup levels are achieved.

No location-specific ARARs were identified for MSP OU2.

2.11.3 Criterion 3: Long-Term Effectiveness and Permanence

Alternative 1 does not provide long-term effectiveness since no actions are taken to reduce risk or exposure to COCs in groundwater. Alternative 2 may provide long-term effectiveness as contaminant concentrations in groundwater are reduced due to natural attenuation processes and monitoring would be in place to document this effectiveness; LUCs would be in place to restrict access to impacted groundwater until the cleanup levels are achieved, meeting long-term effectiveness and permanence for protection against exposure to groundwater contamination. Alternative 2 employs no active remediation and relies on the natural attenuation to achieve the cleanup levels.

Alternatives 3 and 4 would offer a higher degree of long-term effectiveness and permanence through the implementation of remedial technologies. Alternative 3 would implement MNA to address the on-site VOCs not influenced by active treatment, the downgradient portion of the VOC plume, and any residual uranium in the overburden, and ISCR would be designed for the degradation of VOCs in the bedrock. Alternative 4 would achieve the cleanup levels through the implementation of MNA for the low concentration areas of the VOC plume outside of the active treatment area and for any residual uranium present in the overburden groundwater. Pump-and-treat technology would be designed to extract groundwater impacted by COCs in the bedrock. Alternatives 3 and 4 also implement LUCs to restrict access to impacted groundwater until the cleanup levels are achieved, providing long-term effectiveness and permanence. Alternative 3 may have a shorter timeframe to achieve the cleanup levels than the other alternatives but will still rely on MNA to address the residual VOC contamination in untreated areas. Alternative 4 is expected to achieve the cleanup levels in a shorter timeframe than Alternative 2, as the groundwater will be actively remediated.

2.11.4 Criterion 4: Reduction of Toxicity, Mobility, or Volume through Treatment

This evaluation criterion is not applicable to Alternatives 1 and 2. No action occurs under Alternative 1, and Alternative 2 would rely solely on natural processes such as dispersion, adsorption, and dilution to remediate the groundwater at the MSP site. Alternatives 3 and 4 would satisfy the statutory preference for treatment as a principal element through use of ISCR (Alternative 3) or pump and treat technology (Alternative 4).

2.11.5 Criterion 5: Short-Term Effectiveness

No changes in potential exposure to workers or negative impacts on the environment would occur under Alternative 1. Alternative 2 would pose little to no additional health risk to the community and workers in the short term because no significant remedial activities would take place. Alternatives 3 and 4 may have a slight increase in risk to workers during the remedial activities. However, these impacts would be mitigated by health and safety measures.

Alternative 3 is anticipated to produce a prompt reduction of the COCs other than uranium (which is already below the regulatory limits) in the short term since remedial construction and operation activities are designed to target the source area and areas of elevated COC concentrations; LUCs would be implemented within one year; and it is estimated that clean up levels in the source area will be achieved in 10 years. Alternative 4 is anticipated to have a moderate time frame in reduction

of the COCs in the short term as the pump-and-treat applications impact zones of contamination; LUCs would be implemented within one year and the ground water treatment system would be in operation for approximately 30 years to achieve cleanup levels. MNA would be required for a total of approximately 30 years, to address the residual VOC contamination in untreated areas for Alternative 3 and 4.

2.11.6 Criterion 6: Implementability

Alternative 1 involves no action, so there is nothing to be implemented. Applications presented under Alternatives 2, 3, and 4 are proven and no major hindrances have been identified nor are anticipated with their implementation. Due to the limited actions presented under Alternative 2, it is assumed to be the most straightforward alternative to implement.

Since active remediation is proposed under Alternatives 3 and 4, increased complexity and some uncertainty would exist with their implementation. Their technologies have been proven, but problems with implementation are anticipated due to low permeability and the application of these technologies in fractured bedrock flow aquifer units. It is anticipated that these problems could be addressed during the implementation of these technologies. The attainment of necessary permits for potential off-site actions is anticipated to be achievable. In accordance with CERCLA, no permits are required for on-site work. No issues are anticipated with sampling and analysis. Some degree of difficulty may occur during the implementation of the remedial process, which would require careful assessment and engineering judgment to determine operating parameters, and these could create additional uncertainties.

In comparison to Alternative 3, more implementability issues are expected for Alternative 4 due to the need to build permanent infrastructure, need for operator site visits and need to deal with maintenance issues and equipment repair/replacement and possible releases. Also, a pilot study for Alternative 3 and a pump test for Alternative 4 will be needed to develop design parameters and evaluate influence.

2.11.7 Criterion 7: Cost

The estimated costs are as follows:

Estimated Costs	**Alternative 1**	**Alternative 2**	**Alternative 3***	**Alternative 4**
Capital Cost	$0	$1,233,000	$5,471,000	$3,039,000
Average Periodic O&M Cost	$0	$149,000	$162,000	$608,000
Total Cost	$0	$2,711,000	$7,833,000	$11,951,000

Notes:
* Original FS cost estimate revised to include a 30-year duration for MNA and CERCLA Five-Year Reviews.

Alternatives 3 and 4 would have higher costs than Alternative 2.The limited actions involved with Alternative 2 would be the least costly. The technology employed under Alternative 4 would be the most expensive as its average periodic O&M costs are higher and would be required for at least 30 years. Alternative 3 would have a lower total cost than Alternative 4.

2.11.8 Criterion 8: State Agency Acceptance

Comments on the Proposed Plan for the groundwater at the MSP site provided by NJDEP were evaluated and considered during the selection of the final remedy. NJDEP concurred with the Proposed Plan prior to release to the public and agrees with the selection of Alternative 3.

2.11.9 Criterion 9: Community Acceptance.

There were no oral comments received during the virtual meeting nor any written comments submitted to USACE, USEPA, or NJDEP during the public comment period from the community.

2.11.10 Principal-Threat Waste

The NCP establishes an expectation that treatment that reduces the toxicity, mobility, or volume of the principal-threat wastes will be utilized by a remedy to the extent practicable. According to the USEPA, "Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur" (USEPA 1991). Principal threat wastes are not present at this site.

2.12 Selected Remedy

2.12.1 Summary of the Rationale for the Selected Remedy

Based upon an evaluation of all alternatives, Alternative 3 (Treatment with ISCR, MNA, and LUCs) has been chosen as the Selected Remedy for the following reasons:

- The alternative will meet the RAOs as described in Section 2.8.
- The alternative will meet the threshold criteria of protection of human health and the environment, and compliance with ARARs.
- The alternative will produce a reduction in the COC concentration in the short term through use of ISCR technologies since remedial construction and operation activities are designed to target the source area and areas of elevated COC concentrations. This satisfies the preference for treatment as a principal element.
- The alternative will be effective in the long term because all contaminated groundwater will either be treated or restricted from use until the cleanup levels are achieved.
- The results of the groundwater monitoring program will be used to document the alternative progress in attainment of the RAOs and cleanup levels and allow unanticipated results to be evaluated and addressed.

Therefore, it is believed that the Selected Remedy will provide the most balanced approach among the alternatives with respect to the evaluation criteria and costs.

2.12.2 Description of the Selected Remedy

The Selected Remedy will be protective of human health and the environment and will be implemented in accordance with the Federal Facilities Agreement for the project. As discussed in Section 2.9.3, a combination of remedial technologies (ISCR, MNA and LUCs) will be used to treat the contamination at the site. ISCR technologies will treat the VOCs present in groundwater situated in the fractured bedrock on site at the source area. This treatment will eventually eliminate VOCs emanating from the site source area and leave behind groundwater with low concentration VOCs in the downgradient portion of the plume. MNA would address the on-site low concentration of VOCs that are not addressed by the active treatment, the downgradient portion of the VOC plume, and the total uranium present in the overburden. Additional details about the implementation of ISCR and MNA are presented in Section 2.9.3.

The ISCR reagent ultimately facilitates the breaking of chemical bonds, eventually transforming groundwater contaminants into less harmful constituents. The selected reduction reagent would reduce groundwater contaminants such that residual contaminant concentrations are less than the cleanup levels established for the site.

A thorough analysis of available ISCR reagents will be completed during the remedial design to ensure selection of the most efficient and economical reagent. Bench-scale and/or pilot tests will be completed during the remedial design phase to determine the effectiveness, the appropriate concentrations, and the specific volumes of the reagent necessary to be injected. The cost analysis will be further refined to ensure the most economical reagent is chosen. To actively address VOC contamination, and depending on the geology present at the location of an injection, ISCR materials will be injected using one or more of the following technologies:

- Direct injection
- Pneumatic injection
- Pressure pulse injection
- Injection wells

ISCR will be implemented through injection wells placed at the source area near the former sump, the areas of elevated VOC concentrations near ECC-MW-30B and along the downgradient property boundary (see Figure 2-8). In the conceptual design, which will be refined during the actual remedial design, the source area and the areas of higher VOC concentrations injection well system will be configured in a grid of six wells by nine wells (54 wells) and a well spacing of 20 feet. The injection wells in the two North-South (N-S) grid lines nearest to the source area and monitoring well EE-MW-41S will be drilled to a depth of 15 feet. Every subsequent two N-S grid lines will be drilled 5 feet deeper (20 feet, 25 feet), with the last three N-S lines of the grid drilled to a depth of 30 feet.

The injection well systems along the downgradient property boundaries will be configured in three lines totaling 500 feet in length; all of these wells will be drilled to a depth of 50 feet. The lines

will be oriented perpendicular to the groundwater flow. Wells will be spaced every 20 feet for a total of 25 wells. The total number of injection wells at the source area, areas of elevated VOC concentrations near ECC-MW-30B and at the downgradient property boundary will be approximately 79.

Additional injections may be warranted to treat downgradient plumes or areas that may be identified to have a potential impact on receptors. Prior to the injection, monitoring wells located in the target zone (Unit B of bedrock aquifer) will be monitored for the following parameters:

- Contaminant levels
- Total Organic Carbon, ORP, pH
- Manganese, iron, chloride, sulfate
- Dissolved hydrocarbon gases (e.g., ethene, ethane, methane)
- Reagent additives or by-products, as necessary

The amount of VOC reduction will be assessed by comparing results of pre-injection (baseline) and post-injection groundwater samples. The sampling timeframe and frequency, along with the number of samples required for pre-injection and post-injection sampling, will be determined during the remedial design phase. Based on the result of the post-injection sampling, subsequent injections may be required. The remedial design will provide an estimate for the number of injections anticipated.

The use of LUCs will eliminate or minimize the potential for human exposure at unacceptable levels by direct contact or ingestion of groundwater. The appropriate Government agency will be responsible for implementing, maintaining, and reporting on LUCs until the groundwater remedy is complete. The details of these LUCs will be documented in the Remedial Design or Remedial Action Work Plan. The use of ISCR materials injected into the groundwater will reduce concentrations of VOCs and expedite the timeframe required for MNA processes to attain cleanup levels.

Under the Selected Remedy, LUCs will be implemented, such as well restrictions in a groundwater CEA/WRA, where groundwater contamination has been identified, and physical LUCs such as construction worker warnings issued regarding dermal exposure. CEA/WRAs are institutional controls in geographically defined areas within which the NJGWQS for specific contaminants have been exceeded. Designated aquifer uses are suspended in the affected CEA/WRA for the term of the CEA/WRA. When LUCs are implemented (including a groundwater CEA/WRA by the NJDEP) as part of the selected remedy, USACE will work with State and local governments and affected property owners to develop and implement appropriate measures intended to restrict the use of groundwater in the area until the COCs meet cleanup levels.

CEA/WRAs are administered by the State of New Jersey. The state exercises its authority by utilizing a statute that requires the issuance of permits prior to the construction of any groundwater well. The USACE will request the NJDEP to establish a CEA/WRA in the affected areas associated with the MSP site. The USACE will assist the NJDEP in establishing the CEA/WRA. The CEA/WRA will remain in effect until the concentrations of VOCs in the aquifer are below the

cleanup levels. Upon implementation, a CEA/WRA will be utilized in areas of groundwater contamination present on, or off, the site until cleanup levels are achieved.

Groundwater monitoring will be conducted to ensure that concentrations of the COCs are at, or below, their cleanup levels and to document that natural attenuation occurs. The specifics of the monitoring program would be developed in a long-term monitoring plan, during implementation of the remedy, in the Remedial Action phase. To address potential seasonal variation in contaminant levels, USACE will monitor the wells on a quarterly basis for at least the first two years. The data will be examined to determine whether significant seasonal variation is occurring and, if it is, to identify the season in which maximum concentrations occur. After the two-year period, the frequency of monitoring will be reevaluated in coordination with USEPA and NJDEP to determine if changes, such as decreased frequency or amended parameters, are appropriate.

It is important to note that the compliance with cleanup levels for the stated number of sampling results would not be the sole criteria on which a decision to close the well would be based. Other factors, such as seasonal variations that could affect contaminant concentrations during the period in question or whether the well is in a location that could be impacted by high concentrations of contaminants upgradient in the future, would also be considered.

The location and number of monitoring wells will be reviewed on an annual basis. Wells used for environmental monitoring that become damaged or require removal due to construction or other activities will be replaced or repaired, as needed. The need for continuing the monitoring at the location will be evaluated based on existing and expected future groundwater conditions. Water quality results, and the results of the review, will be provided in the annual monitoring report.

The implementation of the Selected Remedy will be considered complete when the long-term average concentrations of the COCs at each individual well do not exceed the cleanup levels for three consecutive sampling events. However, attaining MCLs in a reasonable timeframe could be difficult due to the presence of a complex geology like the bedrock aquifer units at the site. The site concentrations may reach a "plateau condition" above the groundwater cleanup levels wherein the concentrations do not continue to reduce due to matrix diffusion rebound from absorbed contaminant mass that is within the rock matrix and/or immobilized within secondary fractures. To address these conditions, an additional round(s) of injection of ISCR may be evaluated or active treatment may be terminated and transitioned to MNA. Criteria for this evaluation will be developed during the remedial design. If that does occur, and the remedy transitions to MNA, that may also experience a plateau condition where statistical decreasing trends are no longer measured but progress will still slowly continue towards attainment of the cleanup levels over an extended period of time. If plateau conditions are observed, the Selected Remedy and/or RAO may need to be modified (e.g., alternative injection technique or remedial technology may need to be added, or the CEA/WRA and LUCs may need to remain in place indefinitely) in the event findings from the CERCLA Five-Year Reviews determine that the cleanup levels will not be met in what is determined by USACE and the USEPA to be a "reasonable timeframe" (e.g., 30 years). The modification of the remedy and/or RAO would require the preparation of an Explanation of Significant Differences or a Record of Decision amendment.

Based on information currently available, the USACE and the USEPA believe the Selected Remedy meets the threshold criteria and provides the best balance of tradeoffs among the

alternatives with respect to the balancing and modifying criteria. The USACE expects the selected remedy to satisfy the following statutory requirements of CERCLA §121(b): (1) be protective of human health and the environment; (2) be cost-effective; (3) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and (4) satisfy the preference for treatment as a principal element (or justify not satisfying the preference). The selected remedy also complies with ARARs as required by CERCLA Section 121(d), 42 U.S.C. § 9621(d).

2.12.3 Summary of Estimated Remedy Costs

The information in the cost estimate summary (Table 2-6) is based on the best available information regarding the anticipated scope of the remedial alternative. The capital cost for the ISCR technology using direct injection is approximately $5,471,000. The average annual long-term monitoring cost is estimated to be $162,000 per year and represents a net present worth of $7,833,000 over a 30-year monitoring period. This includes the cost to implement MNA activities and LUCs. The detailed cost estimates were provided in the *Final Feasibility Study Report, Groundwater Operable Unit OU2* (USACE 2017a) and updated to 30-year timeframes for MNA and CERCLA Five-Year Reviews in the Proposed Plan (USACE 2020).

2.12.4 Expected Outcomes of Selected Remedy

The Selected Remedy is a combination of remedial technologies to treat the various contaminants present at the site. ISCR technologies will treat the VOCs present in groundwater situated in the fractured bedrock on site at the source area. This treatment will eventually eliminate VOCs emanating from the site source area and isolate groundwater with low concentration VOCs in the downgradient portion of the plume. MNA processes will reduce the downgradient portion of the VOC plume and the uranium present in the overburden.

ISCR applications are anticipated to degrade site COCs with contact and enhance mass reduction. ISCR materials are strong reducing agents and have been successful in treating VOCs present in bedrock groundwater as site COCs (TCE, CT, and chloroform). ISCR will be injected directly into the source area and the areas of elevated VOC concentrations.

The FS estimated a cleanup timeframe of 10 years for treatment of the source area with ISCR. However, a total timeframe of 30 years is estimated to address the residual VOC contamination in untreated areas through MNA. CERCLA Five-Year Reviews will also be required to continue as long as hazardous substances, pollutants, or contaminants remain above levels that allow unlimited use and unrestricted exposure.

2.13 Statutory Determinations

The Selected Remedy satisfies the statutory requirements of CERCLA Section 121 and the NCP, as described below.

2.13.1 Protection of Human Health and the Environment

The Selected Remedy is expected to be protective of human health and the environment in the short- and long-term. It would protect human health and the environment by combining active

remediation with the implementation of LUCs and an MNA program, which would assess the attainment of cleanup levels.

2.13.2 Compliance with ARARs

The Selected Remedy is an active remediation that combines ISCR and MNA and will achieve compliance with ARARs by degrading VOCs present in the bedrock aquifer to below chemical-specific cleanup levels. The primary technology to be used to reduce the uranium in the overburden is MNA. LUCs would be implemented within one year to protect human health and the environment since the reduction of the COCs to concentrations below the cleanup levels would be gradual.

2.13.3 Cost-Effectiveness

The Selected Remedy will provide the most balanced approach among the alternatives, and at a lower cost than Alternative 4.

2.13.4 Permanent Solutions and Alternative Treatment Technologies

The Selected Remedy, which relies on both active treatment and naturally occurring processes, represents the maximum extent to which permanent solutions and treatment are practicable at the site. The Selected Remedy represents the best balance of tradeoffs between the alternatives because it provides a permanent solution, and cost-effectively remediates the property for unrestricted use.

2.13.5 Preference for Treatment as a Principal Element

The Selected Remedy will produce a prompt reduction in the COC concentration in the short term since remedial construction and operation activities are designed to target the source area and areas of elevated COC concentrations. This satisfies the preference for treatment as a principal element.

2.13.6 CERCLA Five-Year Requirements

The Selected Remedy will not result in immediate unrestricted use for groundwater at the MSP site, as contaminants above the cleanup levels will remain on site. CERCLA Five-Year Reviews will continue as long as hazardous substances, pollutants, or contaminants remain above levels that allow unlimited use and unrestricted exposure.

3.0 RESPONSIVENESS SUMMARY

The responsiveness summary serves the dual purpose of: (1) presenting stakeholder concerns about the site and preferences regarding the remedial alternatives; and, (2) explaining how those concerns were addressed and how stakeholder preferences were factored into the remedy selection process.

As discussed in Section 2.3, a virtual public meeting was held on 31 August 2020, to present the Proposed Plan for the Site. The 30-day public comment period extended from 24 August 2020 through 25 September 2020. A transcript of the public meeting is available to the public and has been included in the Administrative Record and Information Repository.

3.1 Summary of Public Comments and Agency Responses

There were no oral comments received during the virtual meeting nor any written comments submitted to USACE during the public comment period from the community. NJDEP concurred with the Proposed Plan prior to release to the public.

3.2 Other Stakeholder Comments and Responses

There were no oral comments received during the virtual meeting nor any written comments submitted to USACE during the public comment period from other stakeholders.

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FIGURES

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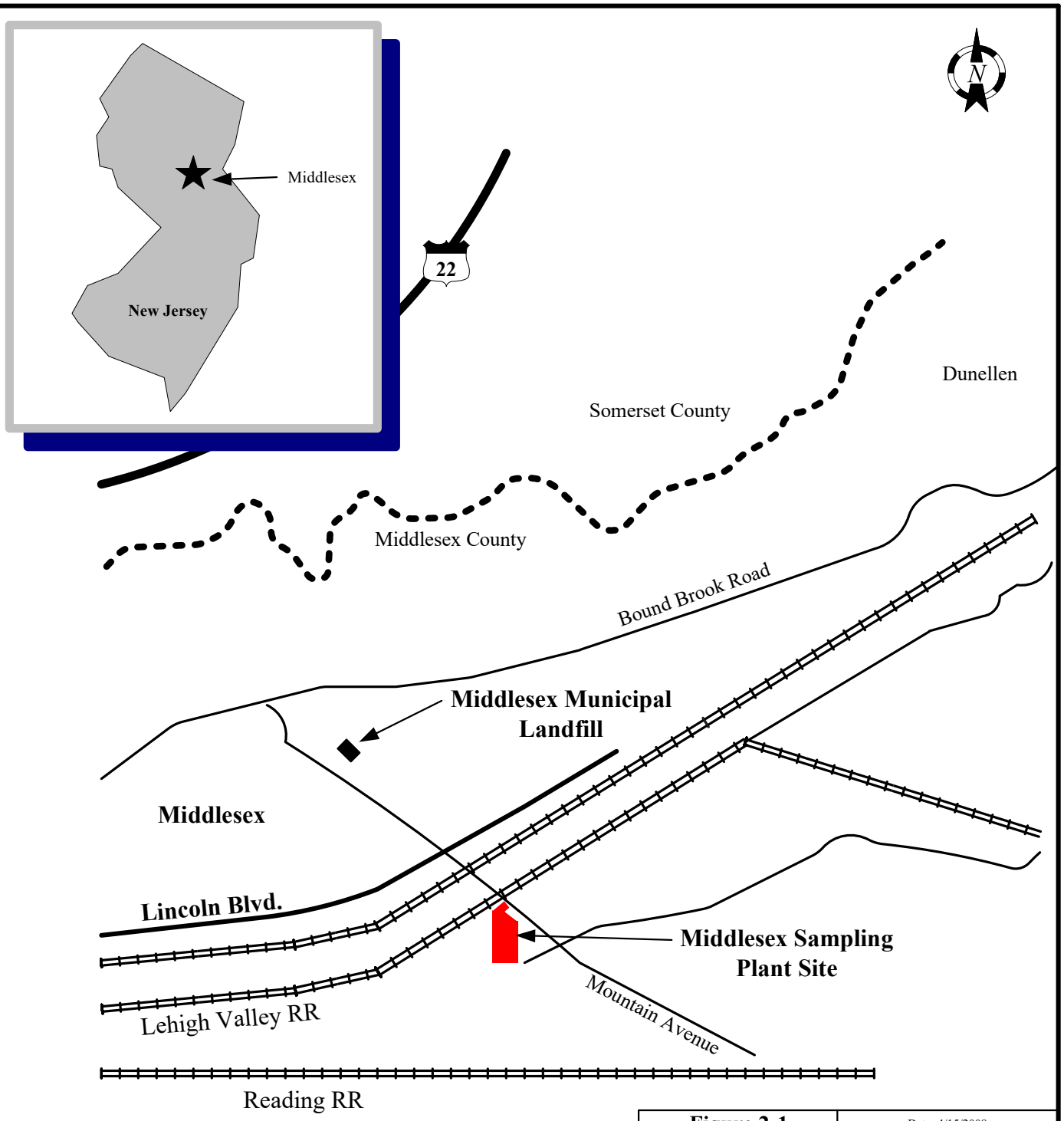

Legend

- County Boundary
- Creeks
- Roads
- Railroads

Not to Scale

Figure 2-1	Date: 4/15/2008
Drawn By: ROW	Checked By: DMM

Middlesex Sampling Plant
Middlesex, New Jersey

Site Location Map

ECC

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LEGEND:

- Overburden Monitoring Well
- Shallow Bedrock Monitoring Well
- Unit B Monitoring Well
- Unit C Monitoring Well
- Unit D Monitoring Well
- Monitoring Well Not Sampled
- Property Line
- Former Location of Subsurface Pipe Chase with Flow Direction
- Approximate Location of Unit Subcrop Fracture/Bedding Plane
- Cross Section Location A-A'/Direction of Bedding Dip
- Fenceline
- Matchline
- Sump
- Former Administration Building
- Former Garage
- Former Process Building
- ★Well is abandoned

Matchline location shown on Figure 1.5

N

0 250 500 1,000 Feet

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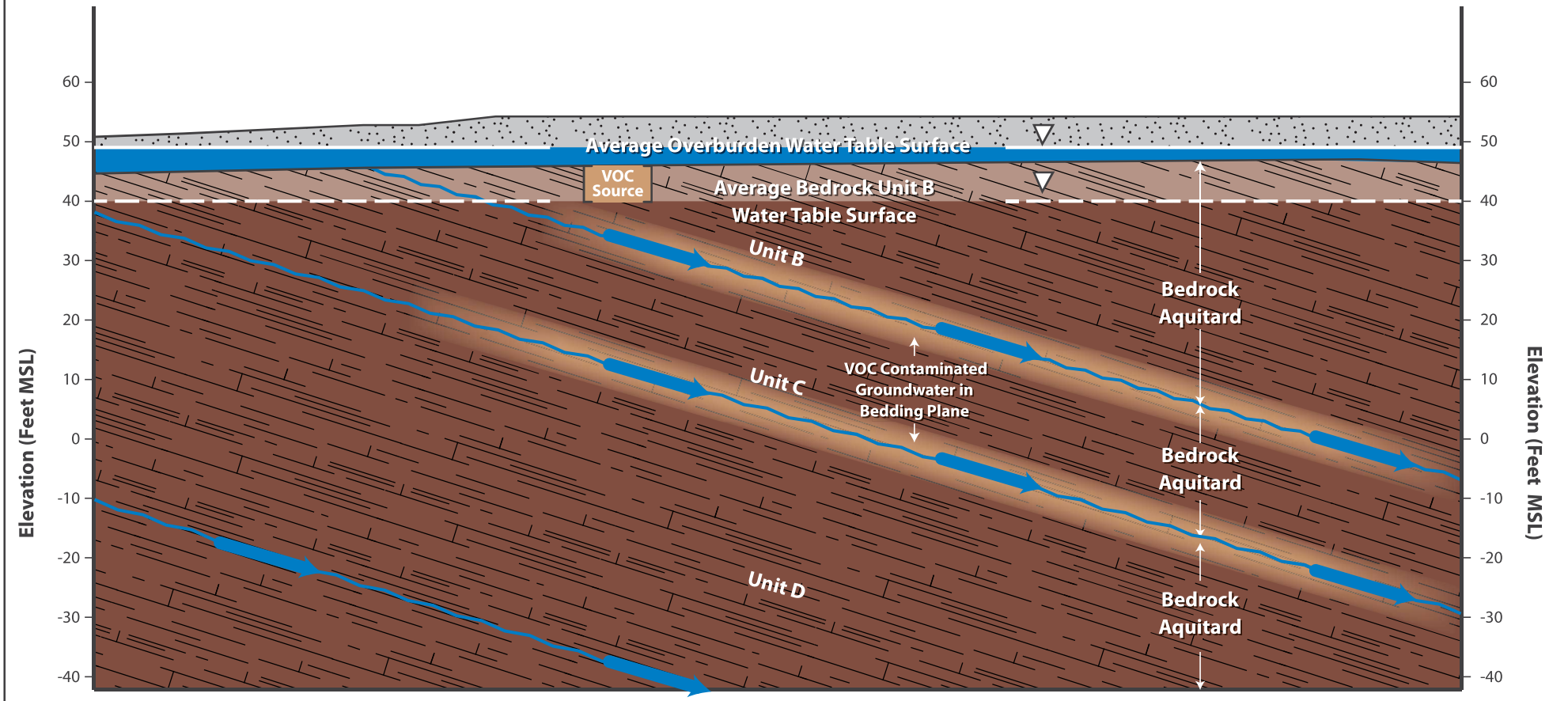
CORPS OF ENGINEERS

Middlesex Sampling Plant
Middlesex, New Jersey

Figure 2-2
Groundwater Monitoring Well Location Map



LEGEND

- Overburden
- Overburden Groundwater Unit
- Unsaturated Bedrock Zone
- Bedrock (Passaic Formation: Red Siltstone and Shale)
- Bedding Plane
- Bedrock Groundwater Flow Direction
- VOC Contaminated Groundwater in Bedding Plane

Vertical Exaggeration=1.5X
Approximate Horizontal Scale=
1 inch Equals 45 Feet
MSL=Mean Sea Level

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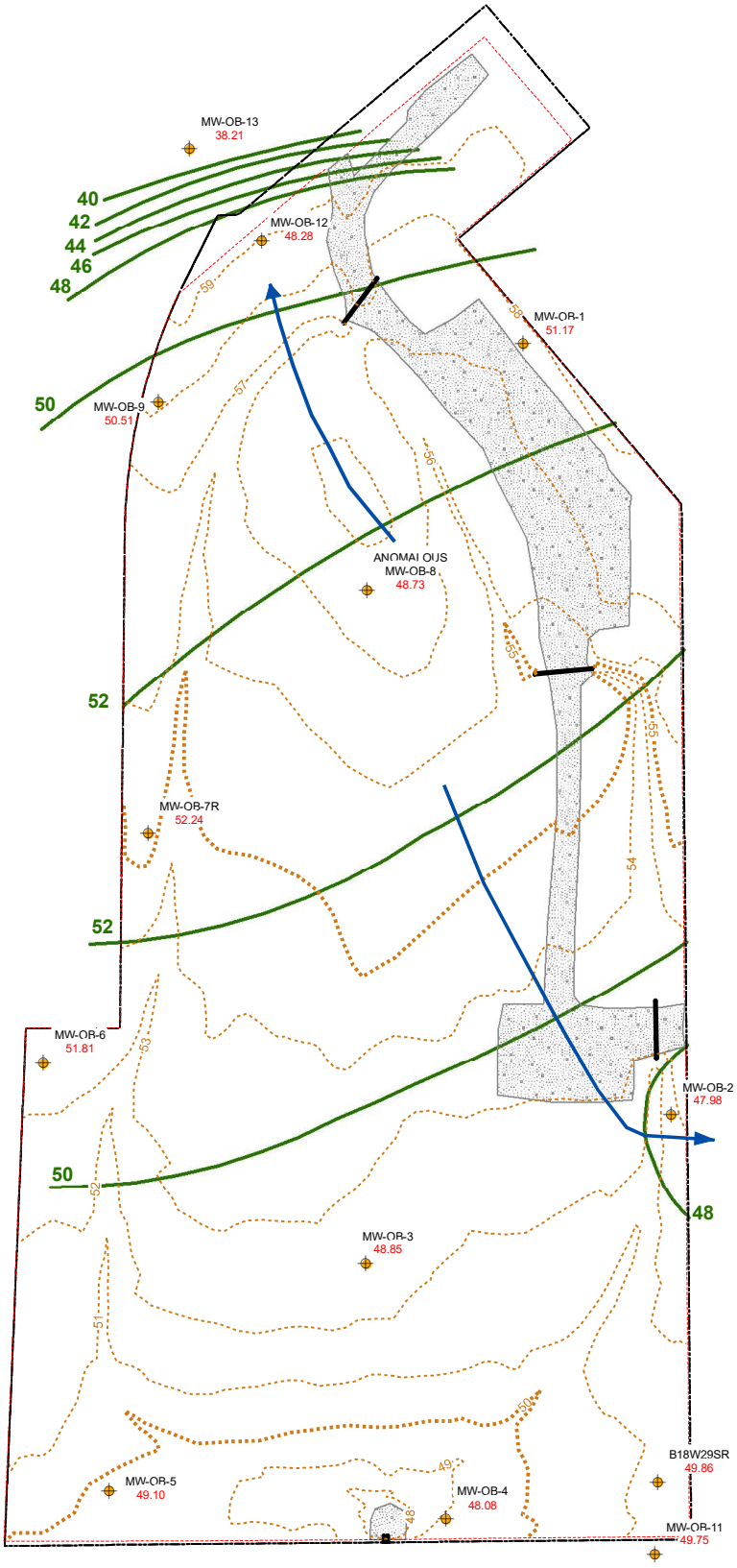
Middlesex Sampling Plant
Middlesex, New Jersey

Figure 2-3
Conceptual Site Model



Legend

- Fenceline
- Property Line
- Elevation Contours (feet AMSL)
- Storm Drains
- 48.73 Overburden Monitoring Well with Groundwater Elevation
- Potentiometric Surface Contours
- Direction of Groundwater Flow
- Gravel Areas

NOTE:
*Wells not used to determine groundwater flow direction.

Coordinate System:
North American Datum 1983 HARN
New Jersey State Plane FIPS 2600
Units: Feet

AMSL = above Mean Sea Level

N

0 25 50 100 Feet

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Middlesex Sampling Plant
Middlesex, New Jersey

Figure 2-4
December 2015 Potentiometric Surface Contours- Overburden Wells

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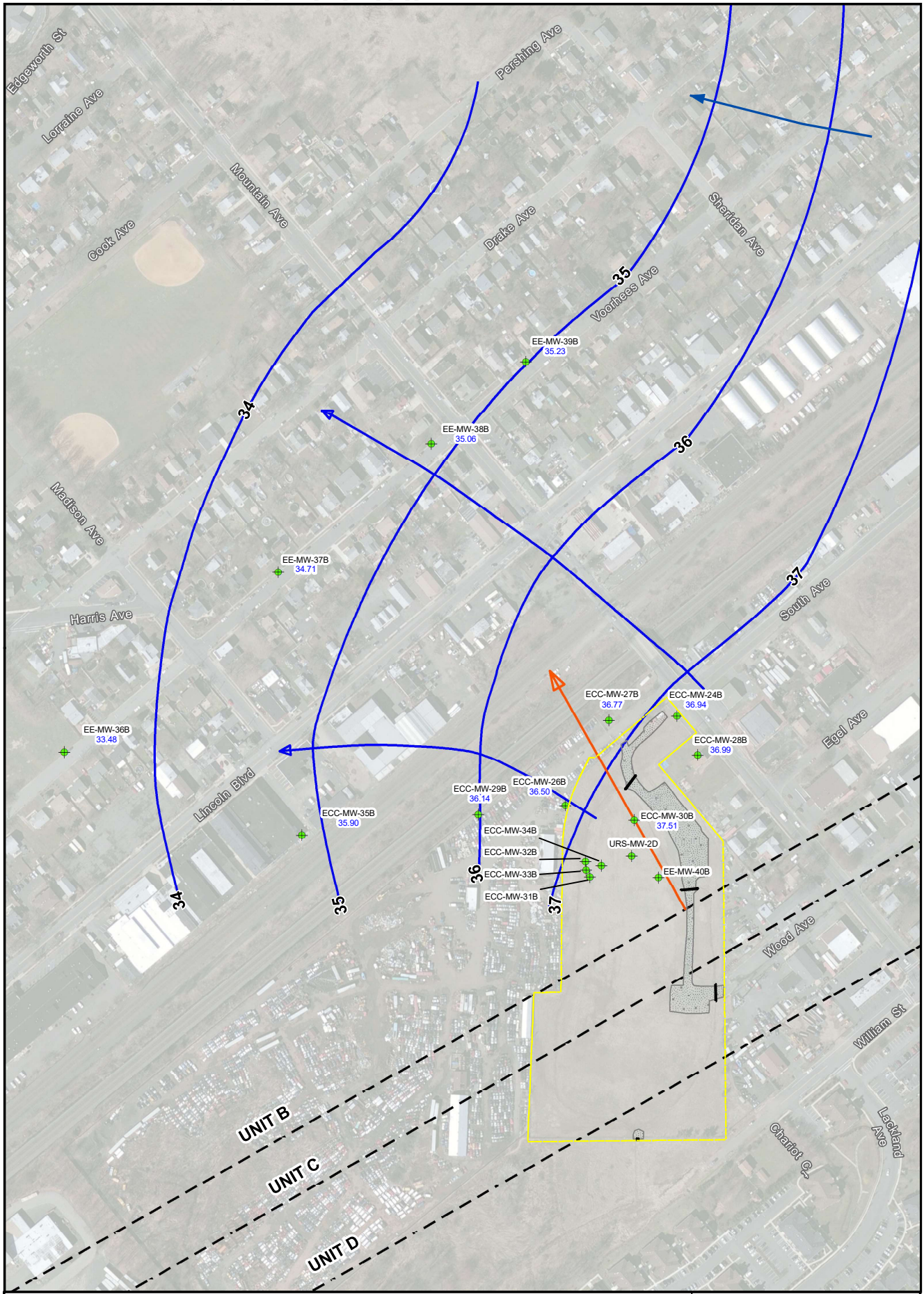

Legend

- Property Line
- Elevation Contours (feet AMSL)
- Storm Drains
- Gravel Areas
- 34.16 Unit B Monitoring Well with Groundwater Elevation
- Potentiometric Surface Contours for Unit B Wells
- Approximate Location of Unit Subcrop Fracture/Bedding Plane
- Direction of Groundwater Flow
- Direction of Bedding Dip

NOTE:
*Wells not used to determine groundwater flow direction.

Coordinate System:
North American Datum 1983 HARN
New Jersey State Plane FIPS 2600
Units: Feet

AMSL = above Mean Sea Level

N

0 50 100 200 Feet

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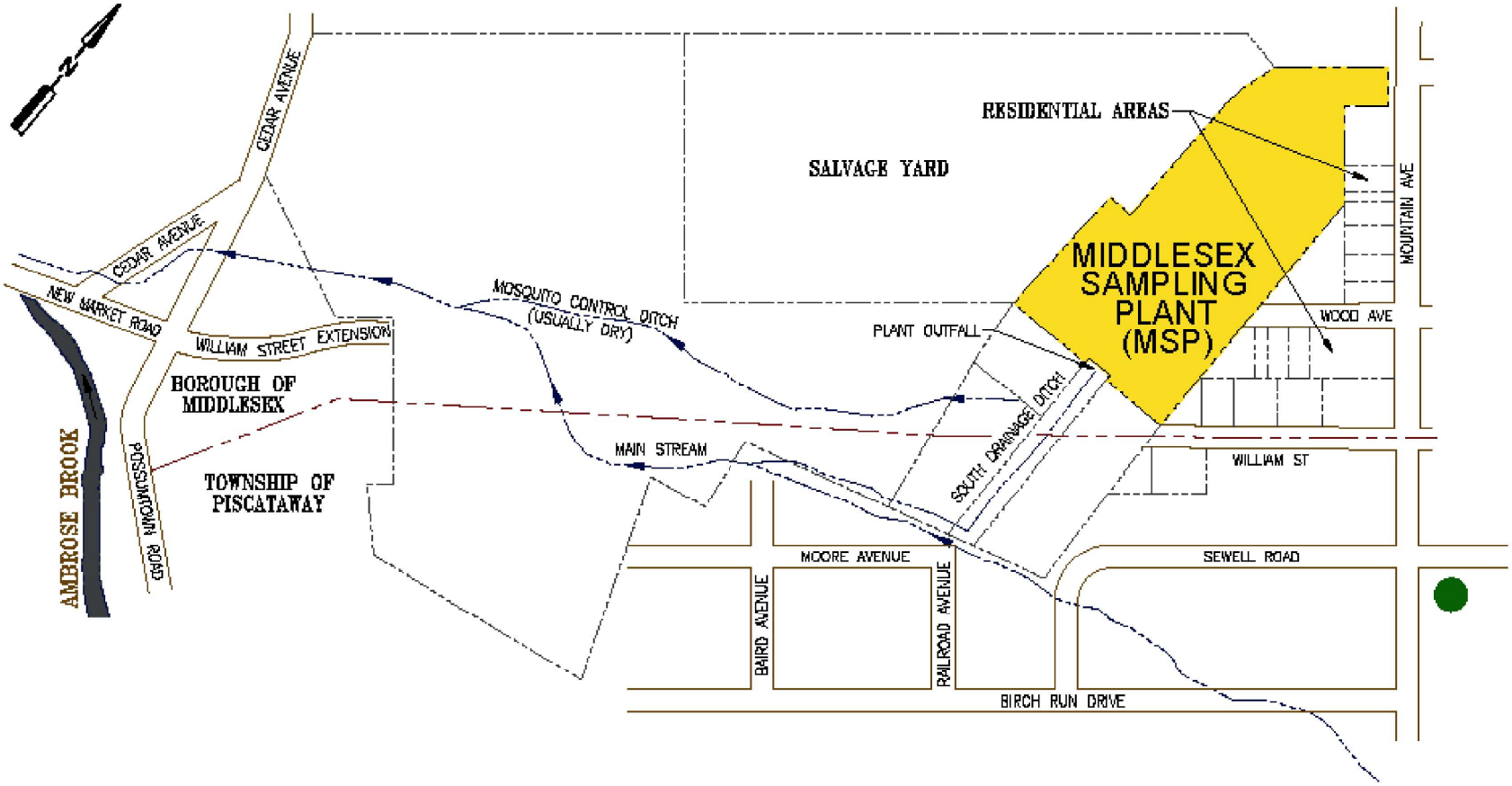
Middlesex Sampling Plant
Middlesex, New Jersey

Figure 2-5
Potentiometric Surface Contours for Unit B Wells (December 2015)



LEGEND:

- TOWN BOUNDARY
- SITE BOUNDARY
- PARCEL BOUNDARY
- ROAD RIGHT OF WAY
- CREEK OR STREAM
- DITCH LINE
- PARK LOCATION

GRAPHIC SCALE

400' 0 200' 400'

REFERENCES:

1.) BNI, DRAWING NO. R99F001.DGN

Drawn by: MGJ	UNITED STATES ARMY CORPS OF ENGINEERS
Date: 02/14/2013	Middlesex Sampling Plant Middlesex, New Jersey
Checked by: ROW	
Date: 03/22/2013	**Figure 2-6a Vicinity Map**
Revised (Date/Initials):	

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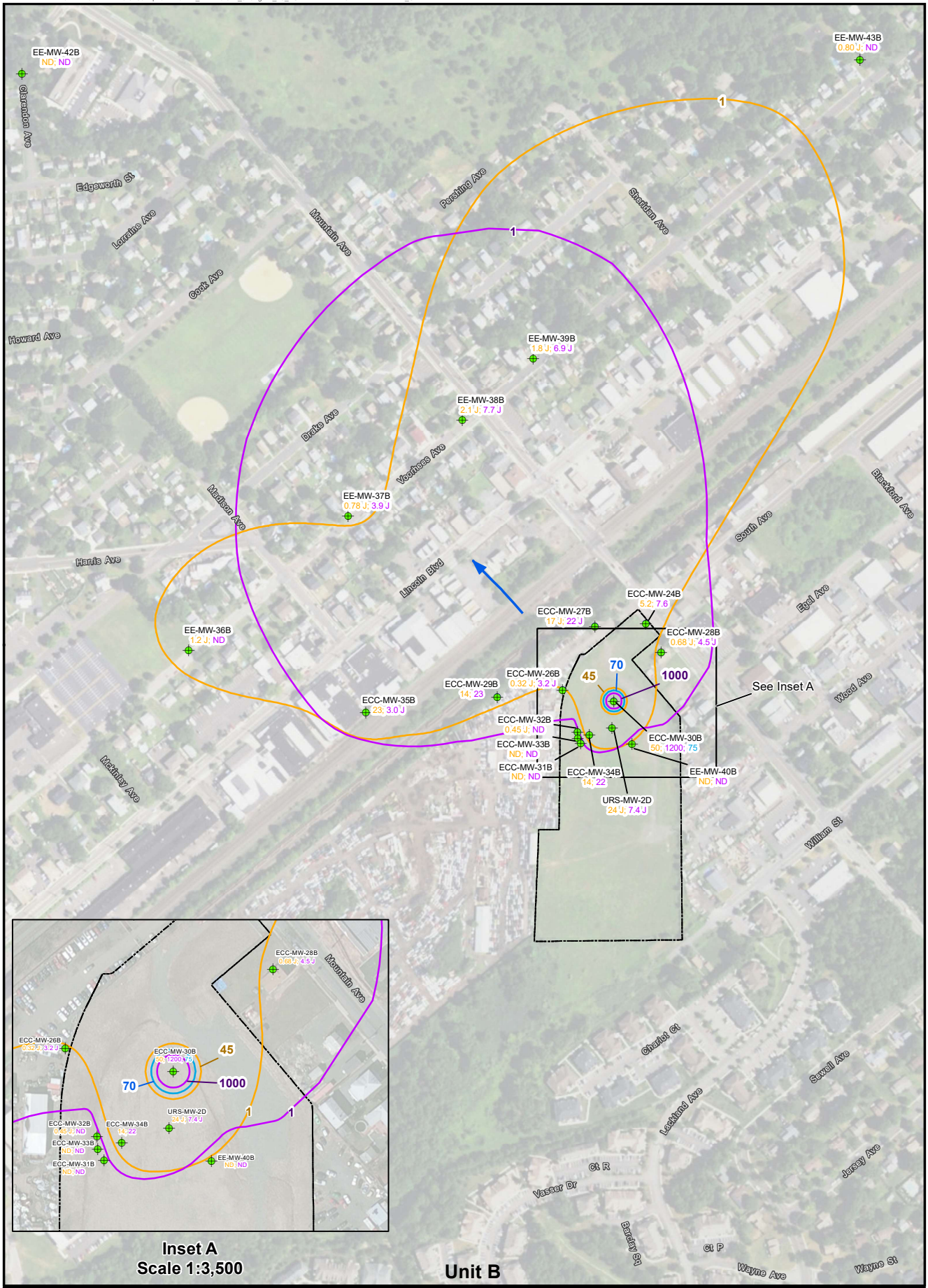

Inset A
Scale 1:3,500

Unit B

Legend

- Unit B Monitoring Well with CT and TCE Concentrations in micrograms per liter (µg/L)
- Property Line
- General Direction of Groundwater Flow - Unit B
- Carbon Tetrachloride Concentration - Unit B
- Trichloroethene Concentration - Unit B
- Chloroform Concentration - Unit B

N

0 100 200 400 Feet

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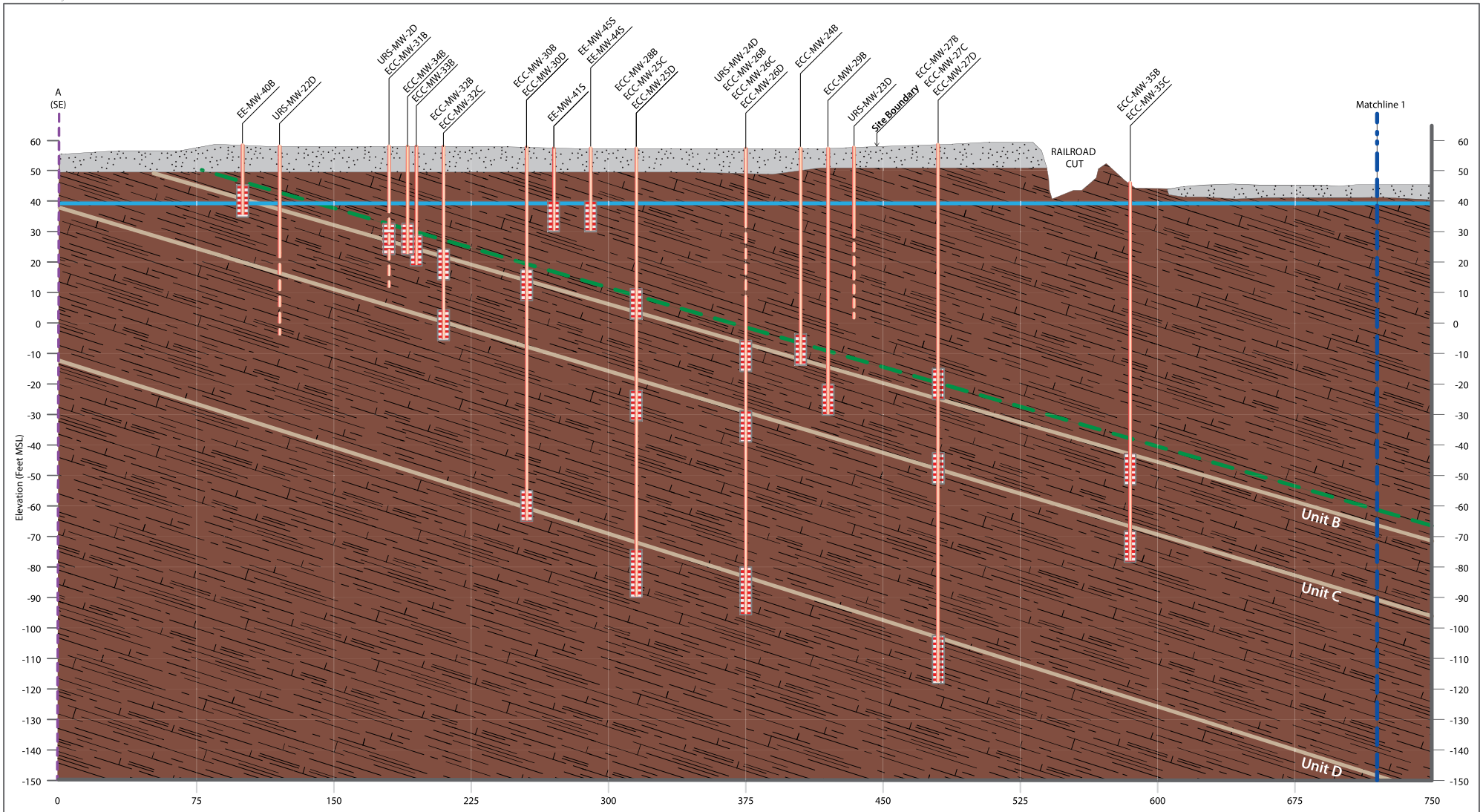
Middlesex Sampling Plant
Middlesex, New Jersey

Figure 2-6b
Unit B
Trichloroethene, Carbon Tetrachloride, and Chloroform Concentration Contours
SE16 2015 - 2016



LEGEND

- Monitoring Well with Well Screen
- Monitoring Well with Open Hole Completion
- Average Bedrock Aquifer Water Table Surface
- Unit Boundary
- Gamma Marker Bed
- Matchline
- Cross Section Location A-A'
- Overburden
- Bedrock (Passaic Formation: Red Siltstone and Shale)

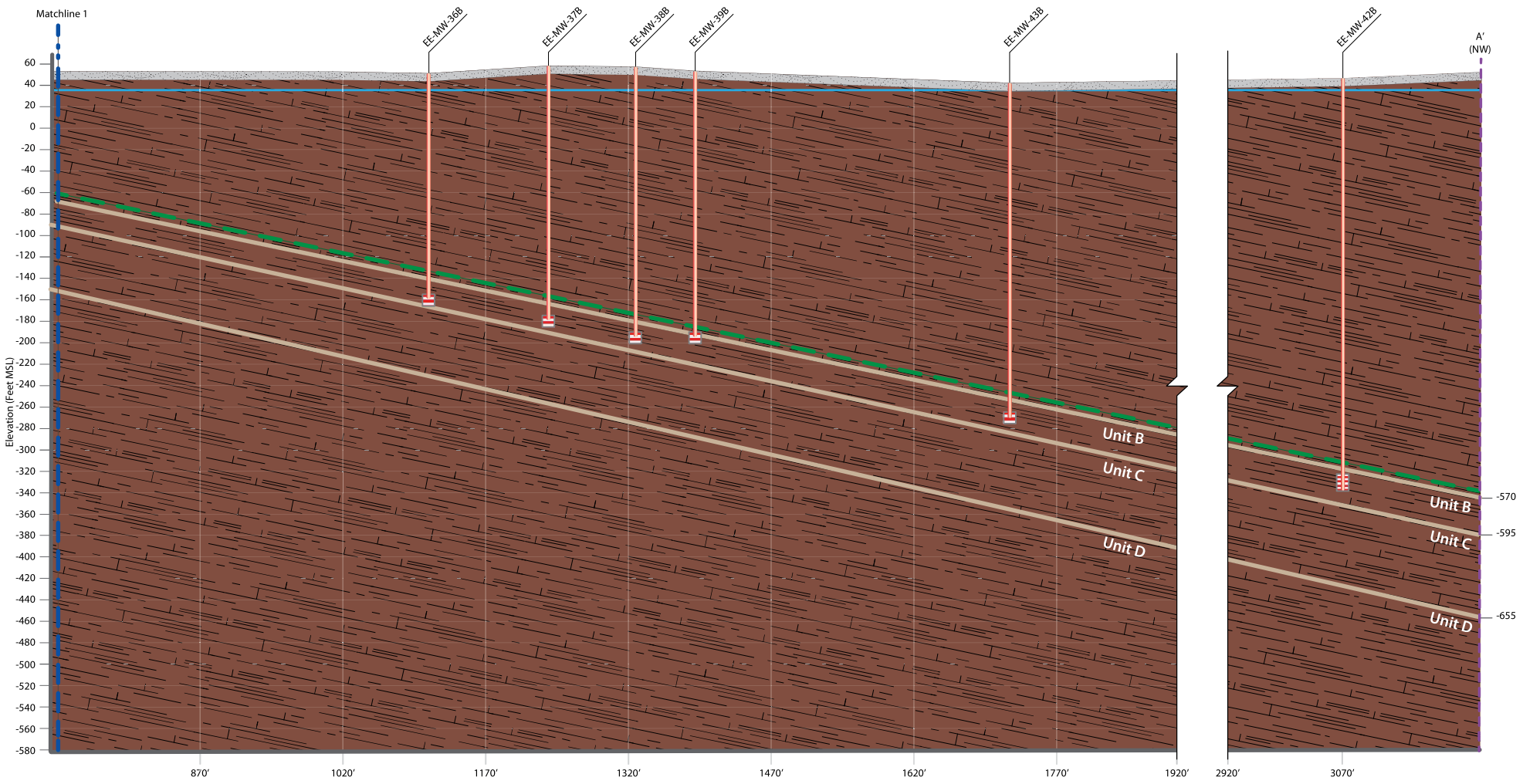
Vertical Exaggeration = 1.5X
Approximate Horizontal Scale: 1.5 inch = 75 feet
MSL = Mean Sea Level
Cross Section Location and Matchline Shown on Figure 3

UNITED STATES ARMY CORPS OF ENGINEERS

Middlesex Sampling Plant
Middlesex, New Jersey

Figure 2-7a
Geologic Cross Section - Onsite Wells

02.003239.0004.03:Figure 2-6b Cross Section Offsite Wells.ai-2/9/18-GRA



LEGEND

Monitoring Well with Well Screen

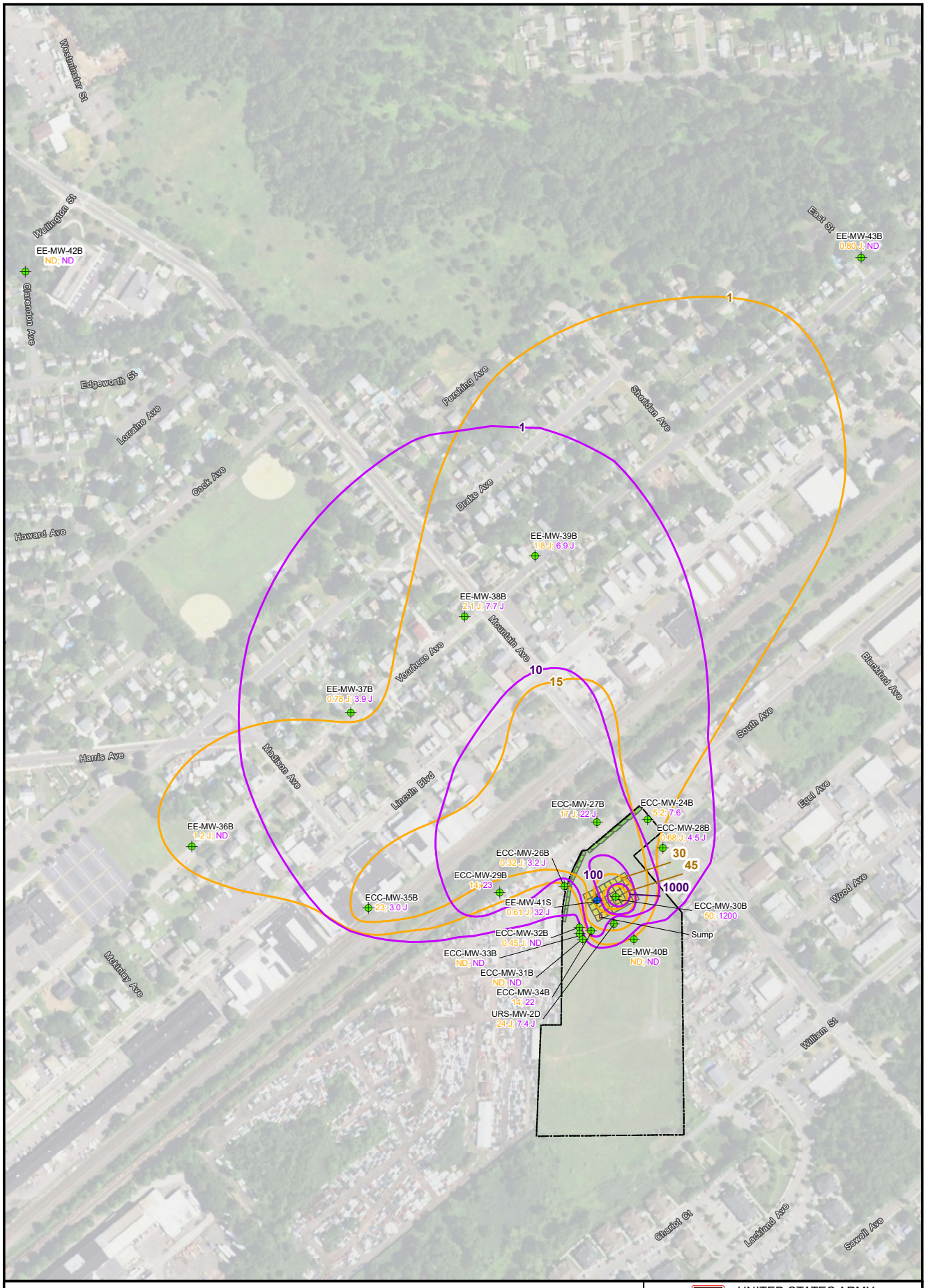
- Average Bedrock Aquifer Water Table Surface
- Unit Boundary
- Gamma Marker Bed
- Matchline
- A' (NW)
- Overburden
- Bedrock (Passaic Formation: Red Siltstone and Shale)

Vertical Exaggeration = 1.5X
Approximate Horizontal Scale: 1.5 inch = 150 feet
MSL = Mean Sea Level
Cross Section Location and Matchline Shown on Figure 3

UNITED STATES ARMY CORPS OF ENGINEERS

Middlesex Sampling Plant
Middlesex, New Jersey

Figure 2-7b
Geologic Cross Section - Offsite Wells



Legend

- Shallow Bedrock Monitoring Well
- Unit B Monitoring Well
- Carbon Tetrachloride Isocontour
- Trichloroethene Isocontour
- Property Line
- Sump
- Proposed Lines of Injection Points/Wells
- Proposed Injection Grid on 20-foot Centers

X; X - Sample Event 16 (SE 16) Concentrations (µg/L): Trichloroethene (TCE); Carbon Tetrachloride (CT)

Notes:

Lines of injection consist of injection points/wells at a 20-foot spacing. Total line length = 500 feet. Total number of points/wells = 25.

6 x 9 injection grid is on 20-foot centers for a total of 54 points/wells.

A total of 79 injection points/wells will inject into the source area, on top of Unit B and into Unit B. Specific injection depths are identified in the text.

Coordinate System:
North American Datum 1983 HARN
New Jersey State Plane FIPS 2600
Units: Feet

N

0 100 200 400 Feet

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CORPS OF ENGINEERS

Middlesex Sampling Plant
Middlesex, New Jersey

Figure 2-8
Alternative 3: In-Situ Chemical Reduction Injection Points/Wells

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TABLES

TABLE 2-1
Summary of Overburden Monitoring Well Total Uranium Detections
Sampling Events 1 Through 16
Middlesex Sampling Plant
Middlesex, New Jersey

WELL ID	Units	SE 1 Aug-08	SE 2 Nov-08	SE 3 Feb-09	SE 4 Dec-09	SE 5 Apr-10	SE 6 Nov-10	SE 7 May-11	SE 8 Aug-11	SE 9 Nov-11	SE 10 Feb-12	SE 11 June-12	SE 12 Aug-12	SE 13 Nov-12	SE 15 Oct-14	SE 16 Nov-15
MW-OB-1	ug/L	3.63	1.83	1.89	1U	1U	1.60	1.20	1U	1U	0.67 J	0.96 J	0.74 J	1.2	0.317	0.321
MW-OB-2	ug/L	3.55	1U	2.98	1U	1U	1.40	1U	1U	1U	1U	1U	0.77 J	0.27 J	0.350	0.112J
MW-OB-3	ug/L	10.40	14.00	7.49	2.59	3.16	5.50	1.40	1.7	1.9	1.6	2.1	0.60 J	3.0	2.62	3.62
MW-OB-4	ug/L	1U	2.98	1.50	1U	1U	0.34	1.2	1U	1U	1U	1U	2.9	1U	0.975	2.04
MW-OB-5	ug/L	7.67	4.78	2.81	2.02	1.99	3.10	1.2	1.4UJ	1.9	2.9	0.79 J	1.8	3.4	0.418	1.94
MW-OB-6	ug/L	3.31	2.75	3.72	1U	1U	9.60	0.65	1U	0.49 J	0.93 J	0.24 J	1U	0.54 J	0.698	2.82
MW-OB-7*	ug/L	**35.10**	**36.10**	**38.10**	10.70	11.10	**41.10**	15	5.8	10.4	**32.3**	9.0	10	**44**	--	--
MW-OB-7R	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	8.64	9.14
MW-OB-8	ug/L	**34.20**	6.89	2.55	1.24	5.69	25.80	1.7	1U	4.4	1.6	4.4	18	11	3.39	2.78
MW-OB-9	ug/L	18.20	6.36	10.50	2.80	4.53	1U	0.72	1U	1.2	0.60 J	0.57 J	4.2	2.3	Dry	0.780
MW-OB-10*	ug/L	4.30	7.23	23.60	19.20	NS	3.60	5.5	1.2	13.2	5.9	**51**	**40**	NS	--	--
MW-OB-11	ug/L	3.38	2.71	3.64	1.12	1.44	0.27	0.81	1U	0.39 J	0.45 J	1U	1U	0.31 J	0.479	0.447
MW-OB-12	ug/L	1U	2.98	4.03	3.03	4.54	8.50	**43.5**	9.3	17.7	5.5	8.4	5.9	7.8	Dry	3.08
MW-OB-13	ug/L	7.15	5.74	2.79	4.03	2.84	3.10	1.9	2.6	2.0	1.8	1.8	2.6	1.8	2.14	2.27
B18W29SR	ug/L	7.65	14.00	7.86	8.72	7.38	1.90	7.9	6.4	10.6	2.2	3.2	0.82 J	3.3	0.738	1.15

Notes: **Bold Font/Blue Cell -** Value at or above the USEPA Maximum Contaminant Level (MCL) of 30 micrograms per liter (ug/L)

Samples were not collected for total uranium during SE 14, only VOCs.

*Wells MW-OB-7 and MW-OB-10 were abandoned in October 2014. MW-OB-7 was replaced with MW-OB-7R near the original location.

Key: ug/L - micorgrams per liter

J - estimated value

U - not detected. Analyte is not present at a level greater than the reporting limit.

UJ - not detected. The reporting limit is estimated.

NS - no sample was collected for analysis due to insuffient water

TABLE 2-2
Summary of Bedrock Monitoring Well Volatile Organic Compound Detections
Sampling Events 1 Through 16
Middlesex Sampling Plant
Middlesex, New Jersey

Volatile Organic Compound	USEPA MCL	NJDEP Criteria	Units	URS-MW-2D															ECC-MW-21D
				SE 1 8/2008	SE 2 11/2008	SE 3 2/2009	SE 4 12/2009	SE 5 4/2010	SE 6 11/2010	SE 7 5/2011	SE 8 8/2011	SE 9 11/2011	SE 10 2/2012	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 9 11/2011
Chloroform (CF)	80	70	ug/L	6.6	5U	1.9	1.3	3.1	0.93	2.5	ND	1.1	1.1	2.6	1.2	0.79	NS	1.78	0.69J	1U
1,1-Dichloroethene (1,1-DCE)	7	1	ug/L	5U	5U	1U	1U	0.7	0.6	1U	0.27	1U	0.29	0.36	0.32	0.31	NS	0.30U	0.57UJ	1U
Carbon Tetrachloride (CT)	5	0.4	ug/L	**12**	**18**	**19**	**15**	**8.3**	**14**	**8**	**7.7**	**20.0**	**14**	**11**	**10**	**15**	NS	**6.28**	**7.4J**	1U
Tetrachloroethene (PCE)	5	0.4	ug/L	5U	5U	1U	1U	1U	0.15	0.15	0.20	1U	0.23	0.23	0.29	0.21	NS	0.30U	0.30UJ	1U
Trichloroethene (TCE)	5	1	ug/L	**25**	**29**	**26**	**27**	**24**	**23**	**23**	**28**	**32**	**26**	**31**	**37**	**27**	NS	**22.8**	**24J**	1U

Volatile Organic Compound	USEPA MCL	NJDEP Criteria	Units	URS-MW-22D															ECC-MW-23D
				SE 1 8/2008	SE 2 11/2008	SE 3 2/2009	SE 4 12/2009	SE 5 4/2010	SE 6 11/2010	SE 7 5/2011	SE 8 8/2011	SE 9 11/2011	SE 10 2/2012	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 9 11/2011
Chloroform (CF)	80	70	ug/L	5U	5U	1UJ	1U	1U	1U	1U	1.8UJ	1.1	0.099	1U	1U	1U	NS	0.30U	0.25UJ	1U
1,1-Dichloroethene (1,1-DCE)	7	1	ug/L	5U	1	1.6	1.6	2.4	2.6	5	4.3	**7.5**	5.9	**9.5**	**7.6**	**9.1**	NS	5.14	**10J**	1U
Carbon Tetrachloride (CT)	5	0.4	ug/L	5U	5U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	NS	0.30U	0.45UJ	1.4
Tetrachloroethene (PCE)	5	0.4	ug/L	5U	5U	1U	1U	1UJ	0.37	**0.63**	**0.43**	**0.78**	**0.64**	**0.85**	**0.72**	**0.81**	NS	**0.42J**	**0.64J**	1U
Trichloroethene (TCE)	5	1	ug/L	5U	5U	1U	0.8	1.1	0.99	1.6	1.4	1.7	1.6	2.2	1.9	1.8	NS	1.04	1.7J	1U

Volatile Organic Compound	USEPA MCL	NJDEP Criteria	Units	ECC-MW-24B						URS-MW-24D													
				SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 1 8/2008	SE 2 11/2008	SE 3 2/2009	SE 4 12/2009	SE 5 4/2010	SE 6 11/2010	SE 7 5/2011	SE 8 8/2011	SE 9 11/2011	SE 10 2/2012	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015
Chloroform (CF)	80	70	ug/L	6.2	4.9	5	NS	4.64	4.3J	47	48	37	32	37	29	26	25	46	19	26	27	19	NS	21.8	19
1,1-Dichloroethene (1,1-DCE)	7	1	ug/L	**9.5**	2.7	4.7	NS	**10.4**	**13**	5U	5U	1U	1.1	1.4	3U	0.4	0.95	1.6	0.72	1.6	13U	13U	NS	0.82J	0.91J
Carbon Tetrachloride (CT)	5	0.4	ug/L	**67**	**30**	**38**	NS	**6.29**	**7.6**	**280**	**270**	**270**	**120**	**220**	**210**	**300**	**220**	**310**	**87**	**230**	**220**	**240**	NS	**206**	**150**
Tetrachloroethene (PCE)	5	0.4	ug/L	2.2	1.1	1.6	NS	1.14	0.92J	5U	5U	1U	1U	1U	1.5U	0.25	0.29	0.37	1U	0.34	13U	13U	NS	0.30U	0.30U
Trichloroethene (TCE)	5	1	ug/L	**11**	**6.6**	**7.3**	NS	**6.37**	**5.2**	**19**	**23**	**20**	**24**	**18**	**17**	**22**	**19**	**23**	**11**	**19**	**19**	**17**	NS	**17.5**	**13**

Volatile Organic Compound	USEPA MCL	NJDEP Criteria	Units	ECC-MW-25C											ECC-MW-25D										
				SE 6 11/2010	SE 7 5/2011	SE 8 8/2011	SE 9 11/2011	SE 10 2/2012	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 6 11/2010	SE 7 5/2011	SE 8 8/2011	SE 9 11/2011	SE 10 2/2012	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015
Chloroform (CF)	80	70	ug/L	5U	1.1	1.1	1.5	1.1	1.2	1.3	0.86	NS	0.98J	0.97J	10U	0.28	0.24	0.48	0.35	0.46	10U	2U	NS	0.60U	0.39J
1,1-Dichloroethene (1,1-DCE)	7	1	ug/L	**81**	**150**	**110**	**200**	**140**	**180**	**120**	**110**	NS	**95.5**	**110J**	**8**	**16**	**14**	**32**	**26**	**44**	**31**	**8.1**	NS	**39.2**	**50J**
Carbon Tetrachloride (CT)	5	0.4	ug/L	**7.4**	**11**	**8.8**	**15**	**9.1**	**12**	**11**	**8.1**	NS	**9.73**	**6.7**	1.4U	0.65	0.43	0.82	0.58	0.92	10U	0.34	NS	0.60U	0.66J
Tetrachloroethene (PCE)	5	0.4	ug/L	**15**	**26**	**20**	**31**	**28**	**32**	**22**	**22**	NS	**16.9**	**15**	1.5U	1.4	1.1	1.9	1.8	2	2.3	0.49	NS	1.66J	1.7J
Trichloroethene (TCE)	5	1	ug/L	**12**	**17**	**16**	**21**	**19**	**21**	**19**	**14**	NS	**16.5**	**15**	**150**	**160**	**120**	**220**	**170**	**190**	**160**	**50**	NS	**108**	**82**

Volatile Organic Compound	USEPA MCL	NJDEP Criteria	Units	ECC-MW-26B											ECC-MW-26C										
				SE 7 5/2011	SE 8 8/2011	SE 9 11/2011	SE 10 2/2012	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 6 11/2010	SE 7 5/2011	SE 8 8/2011	SE 9 11/2011	SE 10 2/2012	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015
Chloroform (CF)	80	70	ug/L	2.9	2.7	3.4	2.6	1.1	1.8	0.83	NS	0.74J	0.41J	9.6	6.6	5.7	6	5.2	5.1	4.8	4.8	NS	3.63	3.5J
1,1-Dichloroethene (1,1-DCE)	7	1	ug/L	1U	1U	1U	1U	1U	1U	1U	NS	0.30U	0.57U	4.3	**8.6**	**11**	**13**	**18**	**26**	**23**	**29**	NS	**48.8**	**63**
Carbon Tetrachloride (CT)	5	0.4	ug/L	**41**	**18**	**27**	**10**	**11**	**21**	**6**	NS	**5.93**	3.2J	**110**	**88**	**78**	**87**	**69**	**80**	**79**	**43**	NS	**48.7**	**31**
Tetrachloroethene (PCE)	5	0.4	ug/L	1U	1U	1U	1U	1U	1U	1U	NS	0.30U	0.30U	2.7	3.1	3.4	4.5	4.9	**6**	**5.8**	**6.8**	NS	**8.34**	**8.4**
Trichloroethene (TCE)	5	1	ug/L	2.9	2.3	3	2.2	1.4	2.1	0.85	NS	0.50J	0.32J	**9.6**	**8.4**	**8.5**	**10**	**8.8**	**9.2**	**8.8**	**8.4**	NS	**7.41**	**7.2**

Volatile Organic Compound	USEPA MCL	NJDEP Criteria	Units	ECC-MW-26D											ECC-MW-27B			
				SE 6 11/2010	SE 7 5/2011	SE 8 8/2011	SE 9 11/2011	SE 10 2/2012	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015
Chloroform (CF)	80	70	ug/L	0.46	0.42	1U	1U	0.3	0.4	0.25	0.24	NS	0.30U	0.25U	3.7	NS	3.29	2.9J
1,1-Dichloroethene (1,1-DCE)	7	1	ug/L	1U	1U	1U	1U	0.17	0.29	1U	1U	NS	0.30U	0.57U	**9.7**	NS	**23.4**	**27J**
Carbon Tetrachloride (CT)	5	0.4	ug/L	3.1	1.7	1.4	1.8	1.3	1.9	2.1	0.71	NS	0.68J	0.48J	**45**	NS	**31.2**	**22J**
Tetrachloroethene (PCE)	5	0.4	ug/L	1.3	0.91	0.67	1.1	0.85	1.2	1.2	0.38	NS	0.38J	0.51J	2.4	NS	2.68	3.5J
Trichloroethene (TCE)	5	1	ug/L	**14**	**8.7**	**7.8**	**11**	**9.4**	**11**	**13**	4.5	NS	**6.37**	**6.4**	**12**	NS	**16.7**	**17J**

Volatile Organic Compound	USEPA MCL	NJDEP Criteria	Units	ECC-MW-27C										
				SE 6 11/2010	SE 7 5/2011	SE 8 8/2011	SE 9 11/2011	SE 10 2/2012	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015
Chloroform (CF)	80	70	ug/L	1.6	1.5	1.4UJ	1.9	1.5	1.3	1.3	1.1	NS	1.1	1.2J
1,1-Dichloroethene (1,1-DCE)	7	1	ug/L	2.1	3.4	3.2	5.6	5	**7**	6.8	**7.8**	NS	**13.2**	**14J**
Carbon Tetrachloride (CT)	5	0.4	ug/L	**16**	**14**	**12**	**18**	**13**	**13**	**16**	**12**	NS	**10.1**	**6.7J**
Tetrachloroethene (PCE)	5	0.4	ug/L	1.6	2	1.8	2.3	2	2.1	2.2	2.1	NS	2.21	1.7J
Trichloroethene (TCE)	5	1	ug/L	**21**	**28**	**26**	**32**	**30**	**31**	**36**	**32**	NS	**36.4**	**30J**

Volatile Organic Compound	USEPA MCL	NJDEP Criteria	Units	ECC-MW-27D											ECC-MW-28B										
				SE 6 11/2010	SE 7 5/2011	SE 8 8/2011	SE 9 11/2011	SE 10 2/2012	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 7 5/2011	SE 8 8/2011	SE 9 11/2011	SE 10 2/2012	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015
Chloroform (CF)	80	70	ug/L	1.3	0.65	1U	0.71	0.41	0.53	0.51	0.41	NS	0.34J	0.40J	1.1	2.2	2	1.2	1.2	1.4	1.2	NS	1.29	1.1J
1,1-Dichloroethene (1,1-DCE)	7	1	ug/L	1U	1U	1U	1U	1U	1U	1U	1U	NS	0.30U	0.57UJ	1.3	2.3	1.9	1.5	1.5	0.9	0.75	NS	0.47J	0.60J
Carbon Tetrachloride (CT)	5	0.4	ug/L	4.5	2.5	1.8	3.2	1.7	2.4	2.9	2.8	NS	2.44	2.0J	4	**8.9**	**10**	**6.4**	**8**	**12**	**9.8**	NS	**8.57**	4.5J
Tetrachloroethene (PCE)	5	0.4	ug/L	0.32	1U	1U	0.28	1U	0.23	0.41	0.33	NS	0.41J	0.57J	0.37	0.46	0.57	0.42	0.32	0.25	1U	NS	0.30U	0.30U
Trichloroethene (TCE)	5	1	ug/L	**5.3**	4.6	4	**6.1**	4.4	**5.7**	**7.5**	**6.9**	NS	**10.2**	**14J**	0.54	1.3	1.4	0.86	0.79	0.9	0.63	NS	0.67J	0.68J

Volatile Organic Compound	USEPA MCL	NJDEP Criteria	Units	ECC-MW-29B											ECC-MW-30B						ECC-MW-30D					
				SE 7 5/2011	SE 8 8/2011	SE 9 11/2011	SE 10 2/2012	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 11 6/2012	SE 12 8/2012	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015
Chloroform (CF)	80	70	ug/L	3	2.8	2.8	2.9	3.1	2.6	2.7	NS	2.48	2.8J	**600**	**380**	**270**	**190**	**161J**	75	2.1	1.7	0.57	NS	0.30U	0.31J
1,1-Dichloroethene (1,1-DCE)	7	1	ug/L	1.1	1.2	1.3	1.9	3	2.7	3	NS	6.66	**11J**	100U	750U	500U	100U	0.30U	0.57U	**8.7**	**7.3**	**9.9**	NS	**12.8**	**18**
Carbon Tetrachloride (CT)	5	0.4	ug/L	**40**	**35**	**42**	**32**	**42**	**36**	**39**	NS	**31**	**23**	**13,000**	**8,000**	**6,100**	**3,600**	**2,360**	**1,200**	**5.6**	3.1	0.7	NS	0.30U	0.45U
Tetrachloroethene (PCE)	5	0.4	ug/L	2.1	2	2.5	2.1	2.5	2.1	2	NS	2.01	2.4J	100U	750U	500U	100U	0.82J	0.52J	0.98	0.76	1.1	NS	0.88J	1.3J
Trichloroethene (TCE)	5	1	ug/L	**12**	**12**	**13**	**14**	**15**	**16**	**14**	NS	**15.9**	**14**	**430**	**230**	**180**	**130**	**121J**	**50**	**51**	**37**	**49**	NS	**53**	**52**

Volatile Organic Compound	USEPA MCL	NJDEP Criteria	Units	ECC-MW-31B				ECC-MW-32B				ECC-MW-32C				ECC-MW-33B				ECC-MW-34B				ECC-MW-35	
				SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 13 11/2012	SE 14 2/2013	SE 15 10/2014	SE 16 11/2015	SE 14 2/2013	SE 15 10/2014
Chloroform (CF)	80	70	ug/L	1U	NS	0.30U	0.25U	0.22	NS	0.30U	0.25U	23	NS	8.47	14J	1U	NS	0.30U	0.25U	1U	NS	0.30U	2.8J	1.7	0.53J
1,1-Dichloroethene (1,1-DCE)	7	1	ug/L	1U	NS	0.30U	0.57U	1U	NS	0.30U	0.57U	2.2	NS	1.05	1.5J	1U	NS	0.30U	0.57U	1U	NS	0.30U	**11J**	1.4	2.56
Carbon Tetrachloride (CT)	5	0.4	ug/L	1U	NS	0.30U	0.45U	1U	NS	0.30U	0.45U	**12**	NS	**61.9**	**47J**	1U	NS	0.30U	0.45U	1U	NS	0.30U	**22**	**5.7**	2.85
Tetrachloroethene (PCE)	5	0.4	ug/L	1U	NS	0.30U	0.30U	1U	NS	0.30U	0.30U	0.46	NS	0.30U	0.30U	1U	NS	0.30U	0.30U	1U	NS	0.30U	2.2J	3	0.48J
Trichloroethene (TCE)	5	1	ug/L	1U	NS	0.30U	0.22U	0.81	NS	0.30U	0.45J	**6.5**	NS	4.89	**5.8**	1U	NS	0.30U	0.22U	0.15	NS	0.30U	**14**	**11**	**26.2**

Volatile Organic Compound	USEPA MCL	NJDEP Criteria	Units	ECC-MW-35C			EE-MW-36B		EE-MW-37B		EE-MW-38B		EE-MW-39B		EE-MW-40B		EE-MW-41S		EE-MW-42B	EE-MW-43B	EE-MW-44S	EE-MW-45S
				SE 14 2/2013	SE 15 10/2014	SE 16 12/2015	SE 15 10/2014	SE 16 12/2015	SE 15 10/2014	SE 16 12/2015	SE 15 10/2014	SE 16 12/2015	SE 15 10/2014	SE 16 12/2015	SE 15 10/2014	SE 16 12/2015	SE 15 10/2014	SE 16 12/2015	SE 16 1/2016	SE 16 11/2015	SE 16 11/2015	SE 16 11/2015
Chloroform (CF)	80	70	ug/L	0.8	15.0U	0.25U	0.30U	0.25UJ	0.62J	0.64J	3.02	3.4J	1.49	1.5J	0.30U	0.25U	**222**	4.1J	0.44J	0.25U	0.27J	5.6
1,1-Dichloroethene (1,1-DCE)	7	1	ug/L	1.2	15.0U	3.8J	0.90J	0.57UJ	0.30U	0.57UJ	0.30U	0.57UJ	0.90J	0.67J	0.30U	0.57U	15.0U	0.57UJ	0.57U	**18**	0.57U	0.57U
Carbon Tetrachloride (CT)	5	0.4	ug/L	0.24	15.0U	0.45U	0.30U	0.45UJ	**5.57**	3.9J	**29.0**	**7.7J**	**14.6**	**6.9J**	0.30U	0.45U	**2,460**	**32J**	0.45U	0.45U	0.95J	**46**
Tetrachloroethene (PCE)	5	0.4	ug/L	1.3	15.0U	0.36J	0.30U	0.30UJ	1.04	0.30UJ	1.28	0.54J	2.84	1.3J	0.30U	0.30U	0.30U	0.30UJ	0.30U	0.30U	0.30U	0.30U
Trichloroethene (TCE)	5	1	ug/L	**8.3**	**33.0J**	**25**	4.10	1.2J	2.47	0.78J	3.17	2.1J	2.92	1.8J	0.30U	0.22U	**62.0**	0.61J	0.22U	0.80J	0.22U	0.97J

Notes: **Bold Font** - value at or above the USEPA Maximum Contaminant Level (MCL)
Blue Cell value at or above the New Jersey Department of Environmental Protection (NJDEP) criteria.

MCL = Maximum Contaminant Level
NJDEP = New Jersey Department of Environmental Protection
NS = not sampled
ug/L = micrograms per liter
U = Not detected. Analyte is not present at a level greater than the reporting limit.
UJ = Not detected. The reporting limit is estimated.
J= Estimated value.

Table 2-3.
Summary of Estimated Excess Cancer Risks and Non-Cancer Hazards
Supplemental Human Health Risk Assessment
Middlesex Sampling Plant (MSP) FUSRAP Site, Middlesex County, New Jersey

Receptor	Age	Exposure Medium	Reasonable Maximum Exposure		Central Tendency Exposure	
			Excess Cancer Risk	Non-cancer Hazard Index	Excess Cancer Risk	Non-cancer Hazard Index
Worker	Adult	Tap Water	**1.4E-03**	**17.3**	9.0E-05	**4.2**
Resident	Young Child	Tap Water	**1.2E-03**	**59.1**	**2.5E-04**	**17.9**
	Adult	Tap Water	**3.4E-03**	**48.6**	**4.6E-04**	**15.9**
Resident Young Child + Adult Totals			**4.6E-03**	NA*	**7.1E-04**	NA*

NA* = Not Applicable; Non-cancer HIs are not additive across age groups.

Values shown in **Bold** exceed EPA's generally acceptable levels (CR=1x10^{-4}; HI=1)

Table 2-4. Cleanup Levels for Groundwater Remedial Action at the MSP Site

Contaminant of Concern	Groundwater Cleanup Levels (µg/L)[a]	Source for Cleanup Level
Uranium	30 µg/L[b]	40 CFR §141.66 (e)
Carbon tetrachloride	1 µg/L[c]	NJGWQS
Trichloroethene	1 µg/L	NJGWQS
Chloroform	70 µg/L	NJGWQS

Notes:

[a] The lowest of USEPA's MCLs (40 CFR Part 141), NJGWQC or PQL (NJAC 7:9C), or NJAC 7:10.

[b] The uranium MCL of 30 µg/L is protective of kidney toxicity and cancer risk associated with uranium-234 and uranium-238 radioactivity (USEPA 2000). Therefore, separate cleanup levels were not established for the uranium isotopes.

[c] Although the New Jersey GWQC for carbon tetrachloride is 0.4 µg/L, the cleanup level selected for this site is 1 µg/L, because 0.4 µg/L is below the reporting limit (i.e., the lowest concentration that can be reported with a reasonable degree of accuracy and precision).

Key:

CFR = Code of Federal Regulations
GWQC = Groundwater Quality Criteria
µg/L = micrograms per liter
MCL = Maximum Contaminant Level

Table 2-5. Comparative Evaluation of Alternatives

Evaluation Criteria	Alternative 1 - No Action	Alternative 2 - MNA and Land Use Controls	Alternative 3 - Treatment with In situ Chemical Reduction, MNA and Land Use Controls	Alternative 4 - Pump and Treat, MNA and Land Use Controls
Overall protection of human health	Not considered protective of human health or the environment in the short or long-term.	Expected to be protective of human health and the environment in the short and long-term.	Would protect both human health and the environment. Use of ISCR materials reduces risk to human health by treating contaminated groundwater above cleanup levels.	Would protect both human health and the environment. The pump-and-treat system reduces risk to human health by treating the extracted groundwater contaminated above cleanup levels.
Compliance with ARARs	Could eventually meet the cleanup levels through natural attenuation. No documentation of this decrease in concentration would be available due to the absence of monitoring. The time frame would be indefinite, cleanup levels would not be achieved within 30 years.	The cleanup levels for the COCs could be met. The estimated time requirement for this alternative is greater than 30 years (and possibly indefinite).	Active remediation. Compliance with the cleanup levels is expected. Complies with cleanup levels by degrading bedrock aquifer COCs to concentrations below cleanup levels. MNA would address untreated areas and total uranium in the alluvium. Implementation of LUCs within 1 year. Active remediation estimated to achieve cleanup levels in the source area in approximately 10 years. However, 30 years is estimated for MNA to address areas not actively treated.	Active remediation. This alternative would comply with cleanup levels for COCs by removal and treatment of groundwater exceeding cleanup levels. Implementation of LUCs within 1 year. The active remediation component and MNA for this alternative is estimated to be 30 years.

Evaluation Criteria	Alternative 1 - No Action	Alternative 2 - MNA and Land Use Controls	Alternative 3 - Treatment with In situ Chemical Reduction, MNA and Land Use Controls	Alternative 4 - Pump and Treat, MNA and Land Use Controls
Short-term Effectiveness	Risk to workers and community is not anticipated. However, continued impact to the community from contamination left in place.	Potential low risk risks to workers and community during MNA process implementation. Implementation of LUCs within 1 year. Reduction of target COCs in groundwater would be monitored.	Anticipated to produce prompt reduction of COCs in the treatment area in the short-term. Slight increase in risk to workers during remedial activities. Monitoring and safety techniques would be implemented to minimize unexpected exposure.	Anticipated to produce prompt reduction of COCs in the treatment areas in the short-term. Slight increase in risk to workers during remedial activities. Monitoring and safety techniques would be implemented to minimize unexpected exposure. Construction activities could result in minimal disturbances.
Long-term Effectiveness	No long-term effectiveness or permanence. The reduction in contamination would be unknown, as no monitoring would be performed.	LUC implementation provides some long-term effectiveness in exposure prevention to groundwater contaminants that remain above the cleanup levels. MNA remedy monitored for effectiveness through well system sampling and data evaluation. Contaminants would remain on the MSP above the cleanup levels for greater than 30 years.	Long-term effectiveness is anticipated. Long-term human health risks reduced due to reduction of COCs to cleanup levels. LUCs would restrict access to contaminated groundwater. Contaminants would remain on the MSP above cleanup levels for approximately 30 years.	Long-term effectiveness is anticipated. Long-term human health risks reduced due to reduction of COCs to cleanup levels. LUCs would restrict access to contaminated groundwater. Contaminants would remain on the MSP above cleanup levels for approximately 30 years.

Evaluation Criteria	Alternative 1 - No Action	Alternative 2 - MNA and Land Use Controls	Alternative 3 - Treatment with In situ Chemical Reduction, MNA and Land Use Controls	Alternative 4 - Pump and Treat, MNA and Land Use Controls
Reduction of toxicity, mobility, or volume through treatment	Aside from natural attenuation processes, reduction in the toxicity, mobility, or volume of contaminated groundwater would not occur.	MNA is a natural treatment process. No direct reduction in toxicity, mobility, or volume of the contaminated groundwater.	Would reduce the toxicity, mobility, or volume of the COCs through treatment. Injection of ISCR materials will reduce COC concentrations in the treatment area. Satisfies statutory preference for using treatment as principal remediation element.	Would reduce the toxicity, mobility, or volume of the COCs through treatment. Groundwater contaminant concentrations anticipated to decline to respective cleanup levels. Satisfies statutory preference for using treatment as principal remediation element.
Implementability	No action will be implemented.	Well design, installation, sampling, and analysis are proven technologies. No implementation problems anticipated. No special permits or materials required; readily implementable.	Technically feasible. Services and materials readily available. Proven technology requiring frequent monitoring to assess effectiveness. Accurate engineering judgment required to determine injection parameters.	Technically feasible. Services and materials readily available. The pumping and treatment processes are proven technologies. A permit would be necessary to discharge treated effluent to off-site publicly owned treatment works, but should be obtainable. Accurate engineering judgment required to determine operating parameters.
Capital Cost	$0	$1,233,000	$5,471,000	$3,039,000
Average Annual O&M Cost	$0	$149,000	$162,000	$608,000
Present Worth	$0	$2,711,000	$7,833,000	$11,951,000

Table 2-6
Detailed Cost Analysis
Alternative 3 In Situ (ISCR) - Middlesex Sampling Plant
Groundwater Operable Unit

Middlesex In Situ (ISCR) Operational Costs					
Cost Item	**Unit**	**Quantity**	**Unit Cost**	**Sub Total**	**Comment**
Plans & Field Work					
Work Plan/Design	Each	1	$ 350,000	$ 350,000	
HASP		1	$ 10,000	$ 10,000	
QAPP		1	$ 45,000	$ 45,000	
Injection Well Install					
Dill Rig Mob/Demob	LS	1	$ 5,000	$ 5,000	
Drilling and completion	Foot	2,510	$ 50	$ 125,500	Install 79 wells in bedrock - Air rotary
Geologist (2)	Hour	400	$ 80	$ 32,000	
Per Diem	Day	40	$ 150	$ 6,000	
Airfare	Each	2	$ 700	$ 1,400	
MW Installation & LUCs	LS	1	$ 135,300.00	$ 135,300.00	Cost of MW Installation & LUCs from FS Table 4-3
			Total	**$ 710,200.00**	
Amendment injection - assume 1 month per injection					
# Injections	**2.5**				
Geologist (2)	Hour	540	$ 80	$ 43,200	Assume 2 people full time for 27 work days (Average 3 wells per day)
Per Diem	Day	70	$ 150	$ 10,500	
Airfare	Each	4	$ 700	$ 2,800	Switch out geologists
EZVI (gal)	gal	32,560	$ 31	$ 1,017,500	Amendment - Assumes 440 gal per well. Cost quote from Tersus Environmental in Wake Forest, NC, 25% markup for shipping and transport.
Amendment Shipping	Lot	14	$ 2,650	$ 37,100	
Injection system shipping	LS	2	$ 7,000	$ 14,000	
Generator rental - 4 weeks	Week	2	$ 2,000	$ 4,000	
Field Personnel (3)	Hour	600	$ 80	$ 48,000	50 hour weeks
Airfare	Each	5	$ 700	$ 3,500	Switch Out
			Subtotal, cost per injection	$ 1,180,600	
			Total	**$ 2,951,500**	
Analytical to support construction					
Misc. parts	LS	1	$ 1,000	$ 1,000	
VOCs	Each	15	$ 100	$ 1,500	Includes QC
MNA Parameters	Each	15	$ 150	$ 2,250	Includes QC
Uranium Analysis	Each	15	$ 50	$ 750	Includes QC
Purge Water Disposal	LS	1	$ 500	$ 500	
Data Validation	HR	40	$ 65	$ 2,600	
Data Validation Report	HR	60	$ 65	$ 3,900	
Injection system fee	LS	1	$ 5,000	$ 5,000	
			Subtotal, cost per injection	$ 17,500	
			Total	**$ 43,750**	
LTM monitoring Year - Quarterly for 2 years					
Sampling Events per year:	**4**				
# Wells per event	**32**				
# Years O&M Monitoring	**2**				
Technician	Hour	240	$ 65	$ 15,600	Assume 3 wells per day
VOCs	Each	36	$ 100	$ 3,600	Includes QC
MNA Parameters	Each	36	$ 150	$ 5,400	Includes QC
Uranium Analysis	Each	36	$ 50	$ 1,800	Includes QC
Purge Water Disposal	LS	1	$ 500	$ 500	
Data Validation	HR	80	$ 65	$ 5,200	
Data Validation Report	HR	125	$ 65	$ 8,125	
Engineer	HR	140	$ 110	$ 15,400	
CAD	HR	40	$ 75	$ 3,000	
Hydrogeologist	HR	40	$ 110	$ 4,400	
			Total	**$ 63,025**	
LTM monitoring Year - Project for 28 years	LS	28	$ 37,983.3	**$ 1,063,533.3**	LTM costs taken from FS Table 4-3
Annual Report	LS	30	$ 50,000	**$ 1,500,000**	
5-year review	LS	6	$ 25,000	**$ 150,000**	
			Capital Cost Subtotal	$4,742,976	
			Capital Cost	**$ 5,471,497**	Updated for location and historical costs
			Average Periodic O&M	$140,531	
			Average Periodic O&M	**$ 162,117**	Updated for location and historical costs
			Net Present Worth Subto	$ 6,790,000	
			Net Present Worth Tot	**$ 7,832,944**	Updated for location and historical costs

Notes:
1. Original cost estimate from the FS, with cost factors taken from RS Means 2016 Cost Indexes: City Cost for New Brunswick, NJ (1.12) and Historical Cost Index for 2016 from 2013 (1.03)
2. Costs are multiplied by an 8% ownership fee and 20% contingency fee to determine subtotals.