FUSRAP

US Army Corps of Engineers ®

FINAL PROPOSED PLAN
MIDDLESEX MUNICIPAL LANDFILL FUSRAP SITE
MIDDLESEX, NEW JERSEY

JULY 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
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
DCGL	derived concentration guideline level
FUSRAP	Formerly Utilized Sites Remedial Action Program
MCL	maximum contaminant level
MML	Middlesex Municipal Landfill
mrem/yr	millirem per year
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
ORAU	Oak Ridge Associated Universities
pCi/g	picocuries per gram
pCi/L	picocuries per liter
RIA	Radionuclide Impacted Area
RAO	remedial action objective
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

1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACE) is issuing this Proposed Plan as part of its public participation responsibilities under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This is a continuation of actions completed at the Middlesex Municipal Landfill (MML) Site, which is being addressed under the USACE's Formerly Utilized Sites Remedial Action Program (FUSRAP). The MML Site has been listed in the U.S. Environmental Protection Agency's (USEPA) Superfund Enterprise Management System database under Identification No. NJD980505499 and is identified by the New Jersey Department of Environmental Protection (NJDEP) as Site No. 5655 with Program Interest No. 024189. The USACE was delegated the authority to clean up the MML Site under the FUSRAP by the Energy and Water Development Appropriations Act of 1998 and subsequent Appropriations Acts.

The USACE is the lead agency for site activities related to the cleanup of early atomic energy program (FUSRAP) contamination, and the NJDEP is the support agency with oversight responsibilities. It is important to note that this USACE action is in response to FUSRAP contamination related to uranium ore disposed of in the landfill only. Other potentially hazardous materials disposed of in the landfill are being addressed by the Borough of Middlesex under a NJDEP 1993 Administrative Consent Order and resulting 1998 Memorandum of Agreement between the two entities as part of the landfill remedial program.

A Remedial Investigation and Risk Assessment were conducted by the USACE in 2014 and 2015 to characterize the nature and extent of soil, surface water, sediment, and groundwater impacted by the disposal of radionuclides at the MML and served to evaluate the risk to human health and the environment. The results of the efforts are detailed in the *Remedial Investigation Volume 1 of 2, and Risk Assessment Volume 2 of 2, Middlesex Municipal Landfill FUSRAP Site, Borough of Middlesex, New Jersey* (USACE 2016). This report is available for review in the site Administrative Record File located at the Middlesex Public Library at 1300 Mountain Avenue. The Administrative Record File contains the documents that are used to form the basis for selection of a response action (40 Code of Federal Regulations [CFR] 300.800). These documents are also available on the USACE website at this web address: https://www.nan.usace.army.mil/Media/Fact-Sheets/Fact-Sheet-Article-View/Article/563012/fact-sheet-middlesex-municipal-landfill/

Residual uranium ore pieces (termed "nuggets") and associated diffuse soil contamination have been observed at the MML as a result of disposal activities from uranium processing conducted under the nation's early atomic energy program. A Feasibility Study was completed by the USACE in 2019 to identify and evaluate remedial alternatives in response to radionuclide contamination identified in soils at the MML Site. The results of the effort are detailed in the *Final Feasibility*

Study Report, Middlesex Municipal Landfill FUSRAP Site, Borough of Middlesex, New Jersey, and this report is available for review in the site Administrative Record File at the Middlesex Public Library.

1.1 Purpose of the Proposed Plan

This Proposed Plan is provided to: (1) summarize previous studies; (2) describe the remedial alternatives considered at the MML FUSRAP Site; (3) identify the preferred USACE remedial action; (4) present the rationale for the preference; (5) provide the support agency an opportunity to review and comment on the preferred alternative; (6) satisfy the requirements of CERCLA 117(a) and 40 C.F.R. § 300.430(f)(2) (the NCP); and (7) solicit input on the concerns and needs of the local community. To satisfy the last point, the USACE is requesting public input on the preferred alternative and on the other alternatives presented within. A public meeting will be held to present the conclusions of the MML Site investigations, elaborate further on the reasons for recommending the preferred alternative, and to receive public comments (see Section 9).

1.2 The Preferred Alternative

FUSRAP-related contaminants were detected in site soils at concentrations that could present a future risk to human health. To address the contaminated soils, the USACE identified a preferred alternative consisting of excavation of soils, use of radiologic soil sorting technology, and offsite disposal of some soils at a licensed/permitted landfill. This alternative would result in removal of FUSRAP related contamination and would allow for unlimited use and unrestricted exposure with regard to FUSRAP contamination. Land use controls or other post-remediation actions such as site inspections for FUSRAP contamination would not be necessary at the site after completion of the remedial action.

What is a FUSRAP-related contaminant?

FUSRAP-related contaminants are radioactive contamination resulting from the Nation's early atomic energy program activities, i.e., related to Manhattan Engineer District or Atomic Energy Commission activities, and hazardous substances associated with these activities. At the MML, FUSRAP contaminants are the radioactive isotopes associated with uranium ore that include Ra-226, U-238, and U-235 decay chains.

The remedy will be considered complete once soils contaminated with radiologic FUSRAP materials above cleanup levels are removed from the MML Site, excavations are filled or graded, and the surface of the landfill is revegetated.

2.0 SITE BACKGROUND

2.1 Site Description

The MML Site is located in the Borough of Middlesex, Middlesex County, New Jersey (see Figure 1-1), approximately 16 miles southwest of Newark, New Jersey. The MML is a 37-acre site and consists of parcels belonging to the Borough of Middlesex and the Middlesex Presbyterian Church (see Figure 1-2). The MML was operated by the Borough of Middlesex from 1940 through 1974 and is no longer in use.

The MML is bordered to the south and east by Pershing Avenue, to the south and west by Mountain Avenue, and to the north by Bound Brook (see Figure 1-2). The MML Site includes portions of the Middlesex Presbyterian Church, Middlesex Borough Hall, and the Borough's recycling center. The majority of the MML Site is owned by the Borough of Middlesex and zoned for municipal use. The northwest portion of the MML Site, behind the Borough Hall, is used for parking. The remainder of the Borough's land is currently undeveloped and has a permanent fence located along Mountain Avenue and Pershing Avenue. The Borough's plan for the area is to reserve it only for active and passive recreational uses and parking requirements associated therewith (Borough of Middlesex Code, General Legislation, Chapter 252, Paragraph 4).

The Middlesex Presbyterian Church property spans 5.95 acres and is zoned single-family residential (see Figure 1-2). The church is located in the western portion of the property and is not within the historic fill area. The eastern portion of the property extends into the historic fill. The church uses a portion of the historic fill area for parking, and the remainder to the east is not developed.

A topographic survey of the MML was conducted in 2002 and showed a relatively flat landfill top with several depressions, possibly associated with subsurface waste subsidence (Zenith NADIR 2002). The northern/northeastern edge of the MML slopes downward approximately 20 feet to the floodplain of Bound Brook. The streambank is flat and dominated by a mature forest and ground or low-level vegetation. Mature trees and other ground cover are present along the south (Mountain Avenue), the southeast (Pershing Avenue) perimeter fence, and on the northern side of the MML along Bound Brook. Individual trees and large bushes are also disbursed throughout the property.

The USACE has identified four areas where FUSRAP materials may be present and recommended further evaluation in the Feasibility Study. These areas were called Radionuclide Impacted Areas (RIAs). RIA-1 is a small area along the fence on the eastern side of the MML Site near Pershing Avenue. RIA-2 is located on the northern slope of the MML. RIA-3 is the largest of the three and located on the western portion of the MML and on portions of the property owned by the Borough of Middlesex and the Middlesex Presbyterian Church. These three areas contained FUSRAP contamination in soils. RIA-4 is the shallow groundwater beneath the MML Site.

Anticipated future land use at MML is an important consideration when determining the appropriate extent of remediation and the remedial goals. Future land use affects the type and frequency of exposure that may occur from residual contamination remaining onsite, which in turn is a consideration in the selection of remedial actions. Conversely, the alternatives selected through the CERCLA remedy selection process may limit the future use of MML Site areas and resources after remedial actions are completed. According to the Borough of Middlesex Code, General Legislation, Chapter 252, Paragraph 4, "the former landfill site [is to] be protected from being used as a residential or commercial property and that the site [is to] be reserved for and used only for both active and passive recreational uses and parking requirements associated therewith." Active recreation refers to uses that require special facilities, courses, fields or equipment, while passive recreation does not require special facilities. Passive recreational uses result in minimal disturbance of a site and use more natural ecosystem-based designs, such as planted fields with walking trails. The future land use described in the Borough of Middlesex Code is in line with the natural resources observed at the MML Site, including the riparian areas, wetland areas, and vegetated open space, which comprise the majority of the MML.

2.2 Site History

The MML was operated between 1940 and 1974, during which time the facility received unregulated municipal and industrial wastes. There is no available record of the amount or type of waste disposal that occurred at the MML over its operational history. Operations at the MML ended in 1974 prior to the enactment of the 1976 Resource Conservation and Recovery Act. Because the Borough of Middlesex closed the landfill prior to January 1, 1982, the Borough is not required to have a Sanitary Landfill Closure Plan (according to New Jersey Administrative Code [NJAC] 7:26-2A.9). Instead, landfill closure was conducted according to standard practices in place at the time, which included the placement of cover material and vegetation.

The Middlesex Sampling Plant (MSP) was an industrial operation that assayed uranium and thorium ores between 1943 and 1955 for the Manhattan Engineer District and the U.S. Atomic Energy Commission (USAEC), predecessor of the U.S. Department of Energy (USDOE). Although the MML and MSP are two separate sites designated under FUSRAP, their interrelationship dictates that the following brief history addresses both the MML and the MSP. The MSP is located approximately 0.5 mile south of the MML. It is no longer operational and the property is owned by the federal government. During operation, the MSP stored uranium ore that was crushed/ground, dried, screened, weighed, assayed, and shipped by the government to private and public enterprises. Spillage occurred during handling and transfer of uranium ore at the MSP resulting in contamination of site soils.

In 1948, the USAEC decided that the pitchblende (uranium ore) storage area at the MSP should be paved. The area was graded smooth and covered with asphalt. The excess soil from the grading operation was transported to the MML. It is estimated that MML received approximately 6,000 cubic yards of soil contaminated with radiologic material generated at the MSP around 1948. The soil contained small quantities of uranium ore and was dispersed over approximately 3 to 5 acres of the MML as fill and cover material for sanitary landfill operations (U.S. Department of Energy [USDOE] 1984). At the time of MML's operation, waste management regulations did not exist; it was not until 1976 that Resource Conservation and Recovery Act was established to regulate the transport, management, and disposal of waste material. The current FUSRAP-related radioactivity at the MML has been determined to be related to the disposal of MSP soils, as waste materials from MSP show similar distributions of radioactive isotopes (USACE 2016).

2.3 Previous Site Investigations and Remedial Actions

USAEC Remediation

Environmental investigations related to the disposal of uranium ore at the MML Site date back to May 1960 when a local civil defense exercise identified elevated radiation levels 20 to 50 times above background levels at the landfill. In response, the USAEC removed approximately 650 cubic yards of radiologically contaminated surface soils from an area of less than 0.5 acre the following year (USDOE 1989).

Radioactive materials remained following completion of this remedial action; therefore, the USAEC placed approximately 24 inches of clean cover material over the remaining radioactive material to lower the external gamma radiation levels to less than 50 microroentgens per hour (USDOE 1989).

USDOE Remediation

In 1986, the USDOE completed a remedial action that consisted of excavating additional contaminated soils from the western portion (including the area remediated in 1960) of the MML (see Figure 1-2). The contaminated soils were transported to the MSP where they were placed in an interim storage waste pile. The USDOE guidelines at the time provided a clean-up standard of an average of 5 picocuries per gram (pCi/g) above background across an area of 100 square meters for each of the radiologic isotopes radium-226 (Ra-226), radium-228 (Ra-228), thorium-230 (Th-230) and thorium-232 (Th-232) for surface soils (top 6 inches). For subsurface soils, the clean-up standard was 15 pCi/g above background across an area of 100 meters for each of these isotopes (USDOE 1989). The excavation covered approximately 4 acres and to depths of up to 18 feet. The remedial action included segregating contaminated materials from clean materials in 1-foot layers. Materials that were determined not to be contaminated were stockpiled and then used for backfill after the excavation was complete. It is estimated that approximately 31,200 cubic yards of radioactive material were excavated from MML, placed in a stockpile at MSP, and then disposed of at a permitted facility by USACE in 1998 under the MSP FUSRAP remedial project (USACE 2010).

During the confirmation survey of the backfilled areas completed by Oak Ridge Associated Universities (ORAU), elevated gamma readings were reported across 10 percent of the excavated area and additional uranium ore nuggets were identified and removed at the surface (ORAU 1987). Following the remedial action, the 5-acre worksite at the MML was certified as compliant with the applicable radiological cleanup criteria and released for unrestricted use based on the criteria used at the time (USDOE 1989).

Borough of Middlesex Radiological Survey and Remedial Investigation

In 2001, the Borough of Middlesex conducted a radiological survey under the direction of the NJDEP as part of conditions set forth in the landfill remedial program. The survey identified elevated radiation levels at the southeast boundary of MML along Pershing Avenue, located approximately 820 feet south of the 1984-1986 USDOE Remedial Action. This area is in the vicinity of a water line extension completed in October 1998 and did not have a radiological survey performed during prior investigations. Ambient dose rates (measured approximately 3 feet above ground) and contact dose rates (measured at ground level) were observed to be distinctly higher when compared to the remaining MML survey area. Analytical sampling was not conducted during the survey (Sadat 2007).

The Borough of Middlesex conducted a Remedial Investigation between 2002 and 2005 under the direction of NJDEP in order to meet the conditional requirements under an NJDEP 1993 Administrative Consent Order and resulting 1998 Memorandum of Agreement between the two entities as part of the landfill remedial program. Activities conducted as part of the Borough Remedial Investigation were performed in accordance with guidance provided under NJAC 7:26E-4.6, Remedial Investigation of Landfills. Additional data were collected in response to a notice of deficiency issued by NJDEP after review of the Remedial Investigation report and a revised report, combined with a conceptual remedial work plan, submitted in 2007. The Remedial Investigation included test pit excavation, soil borings, and installation of temporary wells, piezometers, and soil gas points. Both chemical and radiological data were evaluated during this investigation. The conceptual remedial work plan proposed excavation and offsite disposal of soils from two areas in RIA-3 within or adjacent to the USDOE excavation that was conducted between 1984 and 1986. This proposed remediation is in response to non-FUSRAP-related waste. It proposed removal of 500 cubic yards from one area and 5,000 cubic yards from a second area in order to remove soils contaminated with petroleum, poly-chlorinated biphenyls, and metals (Sadat 2007).

ATDSR Public Health Assessment and Health Consultations

The Agency for Toxic Substances and Disease Registry (ATSDR) performed an independent public health assessment related to determine if contaminants associated with the MSP site located 0.5 miles south of the MML created a hazard to public health (ATSDR 2002). According to the Foreword in the ATSDR Public Health Assessment Guidance Manual, "The mission of the ATSDR is to serve the public by using the best science, taking responsive public health actions and providing trusted health information to prevent harmful exposures and disease related to toxic substances. The ATSDR public health assessment process serves as a mechanism to help ATSDR sort through the many hazardous waste sites in its jurisdiction and determine when, where, and for whom, public health actions should be taken. Through this process, ATSDR finds out whether people living near or at a hazardous waste site are being exposed to toxic substances, whether that exposure is harmful, and what must be done to stop or reduce any exposure." ATSDR collected groundwater samples from all MSP monitoring wells and 17 nearby private wells in February and April of 2000. Given the proximity of the MML to the MSP, the sampling of the 17 private wells is also pertinent to potential groundwater concerns from the MML. Based on its evaluation, the ATSDR determined that no exposures posing public health hazards occur now or are likely to occur in the future. Note that this assessment occurred prior to the USACE removal of contaminated soils at the MSP site in 2008 which further reduces any potential hazard to the public (USACE 2010).

2008 USDOE Radiological Survey

Following the work performed by the Borough of Middlesex and at the request of the NJDEP, the USDOE performed an additional radiological survey. The survey was performed in order to determine whether observed elevated surface radiation levels near Pershing Avenue were indicative of residual deposits of radioactive material in the near-surface soil not remediated under the 1984-1986 USDOE Remedial Action. Locations of observed elevated gamma readings appeared to be consistent with the results of the 2001 radiological survey, primarily concentrated along the Pershing Avenue fence line. In addition, elevated levels of gamma radiation were detected in RIA-3. During the survey, surface and sub-surface soil samples were also collected from five discrete locations across the MML, including three samples within the extents of RIA-3 and two from the Pershing Avenue area (USDOE 2008). The survey findings resulted in a USDOE determination to refer the MML to USACE for further evaluation.

2010 USACE Preliminary Assessment and Site Inspection

Following the CERCLA process, the USACE first performed a CERCLA Preliminary Assessment. The Preliminary Assessment included a review of available literature to determine the potential for the presence of hazardous materials and the potential risk of impacts to human health or ecologic resources with regard to radiologic contaminants at the MML Site. The Preliminary

Assessment determined that potential radiological impacts related to FUSRAP material may be present and progressed to a Site Inspection. During the Site Inspection, data were collected to confirm the Preliminary Assessment findings and support the planning of a Remedial Investigation. The USACE completed the Site Inspection in 2010 with more thorough radiologic surveys, as well as collection of 103 surface and subsurface soil samples (USACE 2010).

2014-2016 USACE Remedial Investigation

The next step in the CERCLA process involved completing a Remedial Investigation to determine the full nature and extent of the FUSRAP contamination. The USACE completed this between 2014 and 2016. The sampling effort included three separate walkover gamma scan surveys to confirm and fill in data gaps identified from the 2010 SI. Surface and subsurface soil sampling and downhole gamma profiling were conducted at 154 locations across the MML Site. Fourteen additional test pits were also installed onsite in RIA-1 and RIA-3 to investigate elevated radiological levels. The test pits were minimal excavations conducted to understand subsurface conditions and were completed to determine if uranium ore nuggets were present at locations with higher radioactivity than at the surface. Additionally, background samples were collected offsite at Lake Nelson on Ambrose Brook in Piscataway to establish background radioactivity of the region (USACE 2016).

Groundwater sampling was also conducted during the Remedial Investigation field program. Thirteen onsite monitoring wells were sampled for radioactive contaminants. Additionally, 11 potable wells in the surrounding area were sampled for radiological data to confirm no elevated contaminants were present and to establish background conditions for the area. Sediment and surface water samples were collected at 10 locations along Bound Brook located upstream, adjacent to, and downstream of the study area. Five additional surface water and sediment samples were collected from remnant and oxbow pond areas on the northern part of the MML Site.

Based on an evaluation of the sample results, the Remedial Investigation recommended four RIAs be evaluated further in the Feasibility Study. The RIAs are shown on Figure 1-2. RIA-1 through RIA-3 are areas where uranium ore nuggets and impacted soils were identified, while RIA-4 is the groundwater below the MML Site.

The area identified along the Pershing Avenue right-of-way with elevated radioactivity was determined to be not related to FUSRAP activities (USACE 2016). The radioactive characteristics found in samples collected from this area were found to be different from uranium ore. Uranium ore has higher concentrations of uranium than are typically found naturally in soils and rock. There are three isotopes of uranium typically found in nature: uranium-238 (U-238), uranium-235 (U-235), and uranium-234 (U-234). All three of these isotopes are unstable, emitting radiation and decaying into other elements, called daughter products. Radium-226 (Ra-226) is an example of a daughter product of U-238. The ratio of isotopes and daughter products found in uranium ore are consistent. Uranium that has been processed will not have these same ratios. The radioactive materials found in samples collected from the Pershing Avenue right-of-way were found to have daughter products of uranium in different ratios than would be seen from the decay of U-238 in uranium ore, thus indicating these radioactive materials were derived from some other material or process. Activities at the MSP did not include processing that would alter the isotopic ratio of the material. In addition, no uranium ore nuggets were found during investigations in this area, as typical of the waste from the MSP. Materials that were found in the ground exhibiting radioactivity at the Pershing Avenue right-of-way were concrete debris and a radioluminescent dial (dial painted with radium). The USACE is authorized to remediate contamination related to early atomic energy program activities only; therefore, the radioactive contamination found along Pershing Avenue cannot be addressed by the USACE under FUSRAP. The Remedial Investigation report provides additional information. This area is to be addressed with the remainder of the MML (i.e., in the Borough’s efforts).

2017-2018 Pilot Study

A pilot study was completed between 2017 and 2018 to evaluate a radiological soil sorting technology and determine its capabilities to support a remedial effort at the MML site. Soils contaminated with FUSRAP materials found in RIA-2 were used in the pilot study. During excavation of contaminated soils, significant amounts of soils that are not contaminated inevitably get excavated along with the contaminated soils. This pilot study helped determine the soil sorter’s ability, effectiveness, and efficiency for separating radiologically contaminated soil from uncontaminated soil. This resulted in reducing the amount of soil estimated to need to be treated or shipped offsite for disposal at a licensed/permitted landfill. The soils were sorted by detecting the radioactivity produced by Ra-226—a decay product of uranium that produces gamma rays (a form of radiation) that are readily detectable. The pilot study concluded that the sorter could reduce the volume of soil requiring offsite disposal by 78 percent and recommended the technology be evaluated in the Feasibility Study as a remedial option.

During pilot study activities, approximately 1,190 cubic yards of soil were excavated from RIA-2 for use in the pilot study. The excavation was guided using a radiological gamma detector and soils were removed until background levels were reached. Uranium ore nuggets and elevated radiological activity were discovered in soils across nearly the entirety of 0.5 acre of RIA-2. The contamination primarily occurred in the soils used for cover material for the MML, with waste intermixed throughout. Fifty-seven uranium ore nuggets of various sizes were removed from RIA-2 soils, and some were selected for use as radiological sources to test the soil sorter. The pilot study report is included as Appendix A of the Feasibility Study report (USACE 2019).

Following the pilot study, a final status survey, which includes a gamma walkover survey and soil sampling program, was conducted in accordance with the *Multi-Agency Radiation Survey and Site Investigation Manual* to evaluate the resulting conditions of RIA-2. The survey concluded that radioactivity in samples collected from this area after the excavation are indistinguishable from background radioactivity. Therefore, remedial action is not necessary in this area (USACE 2019).

3.0 SITE CHARACTERISTICS

The Site characteristics summarized here are described in the Remedial Investigation Report, Middlesex Municipal Landfill FUSRAP Site (USACE 2016) and Final Feasibility Study Report, Middlesex Municipal Landfill FUSRAP Site (USACE 2019).

3.1 Geology and Soils

Prior to landfill operations, the MML Site consisted of a series of wetland depressions. These wetlands were systemically filled during MML activities from approximately 1940 to 1974. The MML Site consists of three main geological strata: overburden, weathered bedrock, and intact or "competent" bedrock. The overburden can be divided into two substrata: the landfill material (including the cover material) and the underlying Quaternary alluvium.

Overburden

Based on USDOE geologic records, within and near the 1984 to 1986 USDOE remedial action area, the overburden material was observed at depths between approximately 16.5 feet below ground surface (bgs) and 34.2 feet bgs. This was on the northerly end of the landfill where soils from the MSP were deposited in RIA-3 (USDOE 1984). Native overburden material, or the Quaternary alluvium, lies beneath the landfill material and consists primarily of gray, red, and brown fine-grained to medium-grained sand and contains occasional clay and silty clay lenses. The alluvium primarily is comprised of sediments eroded from inland areas that have been deposited in floodplains of Bound Brook. Soil borings from the Remedial Investigation field program indicated that landfill material (or non-native material) is present at depths of up to 19.6 feet bgs. Municipal refuse was observed across the MML and within the footprint of the 1984-1986 USDOE Remedial Action area.

Competent and Weathered Bedrock

The Borough of Middlesex is located in the Piedmont physiographic province, which has been defined by the New Jersey Geological Survey as chiefly low rolling plains divided by a series of higher ridges. It is mainly underlain by slightly folded and faulted sedimentary rock of Triassic and Jurassic age and igneous rocks of Jurassic age (New Jersey Geological Survey 2006). The competent bedrock at the MML Site is the Brunswick Shale of the Passaic Formation. As part of the USDOE geological work at the MML Site, competent bedrock was encountered at depths between approximately 20 and 37.5 feet bgs (USDOE 1984).

3.2 Hydrogeology and Groundwater

Groundwater flows through the soil overlaying the bedrock, known as overburden, and bedrock at the MML Site. Groundwater flow through the overburden is generally not significant enough to be used as a potable source. The overburden aquifer observed at MML Site is relatively thin, on the order of feet, and flows north towards Bound Brook while also likely leaking into the bedrock aquifer. The bedrock aquifer, which is the regional aquifer in central and northeastern New Jersey, is contained within fractures of the formation called the Brunswick Shale and provides a water supply source to the area (Michalski and Britton 1997). A geologic formation is a series of bedrock layers with similar characteristics. The groundwater flow is through the fractures in the bedrock. Groundwater onsite at the MML is not used for any potable, commercial, or industrial purposes. Regionally, wells in the bedrock aquifer range from 30 to 1,500 feet bgs. Common well yield rates of the formation are 10 to 500 gallons per minute, although well yields have exceeded 1,500 gallons per minute. The regional bedrock aquifer in the vicinity of MML contains naturally occurring radionuclides (U.S. Geological Survey 2014).

3.3 Nature and Extent of FUSRAP Contamination

The USACE is responsible for addressing FUSRAP waste, which is defined at the MML Site as uranium ore related wastes. Uranium is an element that is commonly found in low levels in the soils and rock of the earth. Uranium ore contains minerals with higher concentrations of uranium than typically found in soils and rock. The three uranium isotopes are U-238, U-235, and U-234. All three of these isotopes are unstable and emit radiation as they decay into other elements. These other elements are called daughter products and are also unstable, emitting radiation until they decay into a stable form of lead. The Feasibility Study identified U-238 and U-235 and daughter products as radionuclides of concern at the MML Site (U-234 is a daughter product of U-238). The types of radiation emitted by each element or daughter product can be different. There are three primary forms of radiation emitted from these unstable elements—alpha, beta, and gamma radiation. Gamma radiation has the highest penetrating power and therefore can travel much farther in the environment than alpha or beta radiation. Because of this, gamma radiation is easily detected. Ra-226 is a decay product of U-238 and an emitter of gamma radiation. In natural uranium ore the Ra-226 activity is equivalent to the U-238 activity. This is known as equilibrium. Ra-226 produces gamma radiation that is easier to measure than that of U-238. In addition, Ra-226 and its daughter products typically comprise the majority of the risk to human health and the environment at sites contaminated with natural uranium ores. Evaluation of the soil data has shown that Ra-226 activity is co-located with U-238 and U-235 and their decay products throughout the Site. The dominance of Ra-226 as a risk contributor and the co-location of elevated activity of the radionuclides show that Ra-226 can be used as a surrogate radionuclide during the remediation. As a result, the summary of the contaminated soils discussed below focuses on the location and extent of Ra-226, a known and readily quantifiable component of the uranium ore, as a surrogate for uranium and daughter products. Targeting Ra-226 for remediation will sufficiently remove the risk associated with radiation while also resulting in a significant reduction in the total activity associated with the uranium isotopes and other radioactive decay products.

The Remedial Investigation indicated that FUSRAP-related radioactive material was present above background levels in surface and subsurface soils at the MML Site. The following sections present a summary of the nature and extent of radionuclide activities for each of the four RIAs that were identified during the Remedial Investigation. It should be noted that surface water and sediment samples were collected from Bound Brook and the oxbow pond onsite as part of the Remedial Investigation. Analysis of these results in the Remedial Investigation report concluded that the samples were similar to background concentrations and do not present a risk to human health or the environment. Therefore, sediment and surface water were not included in RIAs.

Background Levels

Low-level radioactivity naturally occurs in the environment; therefore, in order to evaluate radioactivity at the MML Site it is important to understand level of radioactivity naturally occurring at this location (i.e., the background levels of radioactivity). To determine background levels, 39 samples were collected from areas that would only contain natural levels of radioactivity. For this evaluation, soil samples were collected from the Borough of Middlesex in the following locations: (1) Mountain View Park, located approximately 0.5 mile from the MML Site; (2) Veteran's Park, located on Ambrose Brook south of the MML Site; and (3) the banks of Lake Nelson, also located on Ambrose Brook. The background concentration for Ra-226 was determined to be 1.00 pCi/g.

Soils RIA-1

RIA-1 has a footprint of approximately 0.22 acre and represents the soils and waste material in the vicinity of an area where a uranium ore nugget was found and elevated Ra-226 concentrations have been observed. Radionuclide contamination is limited to a small area within RIA-1 and at depths of up to 2.5 feet from the surface. Figure 3-1 presents the Ra-226 results from samples collected in this area. A summary of the results are presented below.

Summary of Radionuclide Activity in Soils in RIA-1

Parameter	Number of Samples	Background Concentration	Maximum Detection	Average Concentration
Radium-226	35	1.00 pCi/g	10.7 pCi/g	5.01 pCi/g

Soils RIA-2

RIA-2 is located on the northern slope of the MML where 11 uranium ore nuggets and diffuse radioactive soils were discovered during previous investigations. The contaminated soils were removed during the Pilot Study (USACE 2019) and used to study the capabilities of radiological soil sorting technology. A total of 1,190 cubic yards were removed from an area of about 0.34 acre and disposed of in an offsite landfill that is licensed/permitted to handle the waste. The excavation area was backfilled with clean soil from offsite locations and then revegetated with grass.

As discussed in Section 2.3, a radiological survey, including a gamma walkover survey and soil sampling program, was conducted to document the conditions of soils remaining after the contaminated material was removed. The gamma walkover survey was performed over 100 percent of RIA-2 following the excavation. The maximum observed count rate during the gamma walkover survey was below the background levels established for the Remedial Investigation. The survey also included the collection of 27 soil samples, which were analyzed for the presence of Ra-226, a decay product of uranium that typically has the most restrictive cleanup level. The average Ra-226 concentration for the soil samples was 1.00 pCi/g, which is equal to the background concentration of the MML Site, as determined during the Remedial Investigation (USACE 2019).

Two statistical tests were performed using the survey data in accordance with the *Multi-Agency Radiation Survey and Site Investigation Manual*, which is used to determine if a site is in compliance with a radiation dose or risk-based regulation. Both statistical tests indicated that the Ra-226 concentrations were indistinguishable from background concentrations. Therefore, no additional remedial action is necessary in RIA-2.

Soils RIA-3

RIA-3 has a footprint of approximately 7.4 acres and includes the area that the USDOE excavated during 1984 to 1986. The soil radionuclide activity and uranium ore nugget activity observed together in RIA-3 resulted in an exposure point concentration that was determined to pose a potential unacceptable cancer risk. Further discussion of risk is presented in Section 4.0. Figure 3-2 presents the Ra-226 results from soil samples collected in this area. A uranium nugget collected from RIA-3 was sent for analysis, as well. A summary of the results are presented below:

Summary of Radionuclide Activity in RIA-3

Parameter	Number of Samples	Background Concentration	Maximum Detection	Average Concentration
Soil				
Radium-226	1,053	1.00 pCi/g	185 pCi/g	5.01 pCi/g
Uranium Nugget				
Radium-226	1	1.00 pCi/g	142,000 pCi/g	

The contaminated soils in RIA-3 are assumed to originate from historical disposal of contaminated soil wastes from MSP operations and that had remained after the 1984-1986 USDOE Remedial Action effort. The Remedial Investigation data indicated that radioactive material above background levels was distributed across RIA-3, particularly in the footprint of the 1984-1986 USDOE Remedial Action. Additionally, the Ra-226 isotope served as a good indicator of elevated concentrations for the other radionuclides. Radionuclide contamination was identified in samples at depths of up to 14 feet bgs.

Groundwater RIA-4

During the Remedial Investigation activities, 13 monitoring wells were sampled onsite. Nine of these wells are completed in the overburden and four of them are in the bedrock (see Figure 3-3). In addition, 14 offsite potable wells were sampled to establish a background of naturally occurring radionuclide activity for the area. Groundwater samples were analyzed for the presence of radionuclides and compared to USEPA Maximum Contaminant Levels (MCLs) established in the National Primary Drinking Water Regulations as presented in 40 CFR 141. Relative to offsite potable wells and the MCLs, the nature and extent of radioactivity in onsite groundwater is comparable to that in background levels and indicated that radioactive contaminants in soils at the MML were not migrating to groundwater. No samples showed concentrations of radionuclides above MCLs. The results of the sampling event conducted in 2015 are summarized below:

Summary of Radionuclide Activity in RIA-4

Parameter	Number of Samples	EPA MCL	Maximum Detection	Average Concentration
Onsite Monitoring Wells				
Ra-226+Ra-228	13	5 pCi/L	3.32 pCi/L	0.857 pCi/L
Total Uranium		30 µg/L	6.6 µg/L	1.5 µg/L
Gross Alpha		15 pCi/L	10.4 pCi/L	2.62 pCi/L
Gross Beta		50 pCi/L*	44.8 pCi/L	15.1 PCi/L
Offsite Potable Wells				
Ra-226+Ra-228	14	5 pCi/L	1.72 pCi/L	0.636 pCi/L
Total Uranium		30 µg/L	1.3 µg/L	1.0 µg/L
Gross Alpha		15 pCi/L	2.01 pCi/L	3.40 pCi/L
Gross Beta		50 pCi/L*	4.14 pCi/L	2.25 pCi/L

Note:
*Although not applicable to MML, the concentration of 50 picocuries per liter (pCi/L) is used as a screening level or “trigger” concentration to determine if additional testing is necessary to determine if levels may be greater than the dose-based USEPA man made beta emitters MCL of 4 mrem/yr (40 CFR 141.26(b)(1)(i)).

4.0 SUMMARY OF RISKS

A Baseline Human Health Risk Assessment (BHHRA) was conducted for the MML Site in 2016 as part of the Remedial Investigation (USACE 2016). It was conducted in order to determine the current and future excess lifetime cancer risks and radiation doses (as effective dose equivalents) from exposure to radioactivity detected at the MML Site. For simplicity, the excess lifetime cancer risk will be referred to as "risk" or "cancer risk" and the effective dose equivalents will be referred to as "dose" or "radiation dose" for the remainder of this document.

Currently, the MML Site is not occupied and little to no exposure to Site contaminants is occurring. However, the USACE evaluated adverse health effects to human populations should use of the MML Site change in the future. The Borough of Middlesex property is zoned as municipal and the Middlesex Presbyterian Church property is zoned as residential. The portion of the church property that is within the extents of the MML and RIA-3 is currently used for parking.

The Borough's plan for the area is to create a recreational park on top of the MML. The full details of the risk assessment are available in *Risk Assessment Volume 2 of 2, Middlesex Municipal Landfill FUSRAP Site, Borough of Middlesex, New Jersey* (USACE 2016). The scenarios evaluated for the risk assessment are as follows:

- Trespassers and recreational users, both adult and adolescent, that may come into contact with surface soil, surface water, and sediment;
- Outdoor maintenance workers that may come into contact with surface soils;
- Future indoor workers that may come into contact with surface soils as well as groundwater;
- Construction or utility workers that may come into contact with surface and subsurface soils as well as groundwater in the overburden; and
- Future residents, both adult and child, that may come into contact with surface and subsurface soils as well as groundwater.

A Screening Level Ecological Risk Assessment was also conducted as part of the 2016 Remedial Investigation to evaluate ecological hazards from exposure to radioactivity detected in surface water, sediment, and surface soil. The Screening Level Ecological Risk Assessment evaluated the potential exposure and hazards to the following receptors:

- Aquatic plants, benthic invertebrates, freshwater fish, semi-aquatic birds and mammals, reptiles, and amphibians exposed to surface water and sediment;

- Terrestrial birds and mammals exposed to surface water; and
- Terrestrial plants, soil invertebrates, birds, mammals, reptiles, and amphibians exposed to surface soil.

What is Risk and How is It Calculated?

A BHHRA is an analysis of the potential adverse health effects caused by hazardous substances releases from a site in the absence of any actions to control or mitigate these releases; it estimates the "baseline risk" in the absence of any remedial actions at the site under current and future land uses. To estimate this baseline risk at a CERCLA site, a four-step process is used to assess site-related human health risks for reasonable maximum exposure scenarios. These steps are identified below.

Data Evaluation: *The data evaluation step identifies the radionuclides of concern at the site in various media (e.g., soil, groundwater, surface water, sediment) based on such factors as toxicity, frequency of occurrence, fate and transport of the radionuclides in the environment, activities of the radionuclides in specific media, mobility, and persistence.*

Exposure Assessment: *In this step, the different exposure pathways through which people might be exposed to the contaminants identified in the previous step are evaluated. At this site an example of an exposure pathway is indirect exposure which results from being in close proximity to soils contaminated with radionuclides that emit radiation. The assessment takes into account exposure to radionuclides and the potential frequency and duration of the exposure. Using these factors, a "reasonable maximum exposure" scenario, which portrays the highest level of human exposure that could reasonably be expected to occur, is calculated.*

Toxicity Assessment: *The toxicity assessment determines the types of adverse health effects associated with radionuclide exposure and the relationship between the magnitude of exposure (dose) and severity of adverse effects (response). Radiation dose is estimated by using modeling software that allows the user to input site specific parameters such as the concentration of radionuclides, the time a person may spend on the property, and types of activities a person is likely to engage in while on the property under different scenarios. Potential health effects are radionuclide specific and may include the risk of developing cancer over a lifetime.* ***Risk Characterization:*** *This step summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of site risks. Exposures are evaluated based on the potential risk for developing cancer. The likelihood of an individual developing cancer is expressed as a probability. For example, a 10^{-4} cancer risk means a "one-in-ten-thousand excess lifetime cancer risk", or one additional cancer in a population of 10,000 people as a result of exposure to site contaminants under the conditions explained in the Exposure Assessment. Current federal NCP regulations for acceptable exposures are an individual lifetime excess cancer risk in the range of 10^{-4} to 10^{-6} (corresponding to a one-in-ten-thousand to a one-in-a-million excess lifetime cancer risk).*

4.1 Baseline Human Health Risk Assessment Results

Risk to human health was evaluated as the probability of an individual developing cancer from radionuclide exposure. As defined by the NCP, a calculated cancer risk between 1 in 10,000 and 1 in 1,000,000 is recognized as an acceptable probability of an individual developing cancer. A cancer risk greater than 1 in 10,000 generally indicates an increased risk of an individual developing cancer and results in a risk management action.

The BHHRA evaluated the cancer risk for each receptor by first comparing the risk to the background risk value. If the risk for the receptor was found to be greater than the background, then the cancer risk was compared to the acceptable risk range noted above.

In addition to cancer risk, radionuclide exposure is evaluated as the annual radiation dose to an individual. The doses to each receptor are summed over all pathways to represent a total estimated dose of radiation. The BHHRA evaluated the dose by comparing the dose from the MML Site to the background dose value.

The potential for non-cancer health effects, such as kidney toxicity, was not evaluated for all radionuclide exposures because the USEPA classifies the radionuclides of concern as human carcinogens, which is presented as cancer risk in the risk assessment. The one exception is for total uranium, which has the potential to pose both radiotoxicity and chemical toxicity. For soil, a reasonable exposure concentration for total uranium was determined for each RIA. The concentrations were evaluated against the USEPA preliminary remediation goal for residential soil (USEPA 2016a), and the concentrations were determined to be less than this preliminary remediation goal. The risk assessment concluded that non-cancer health effects from the chemical toxicity of uranium are not anticipated. For groundwater, the maximum total uranium concentrations were evaluated against the USEPA regional screening level for tap water (USEPA 2016b), and the concentrations were determined to be less than the screening level. As a result, non-cancer health effects from chemical toxicity of uranium are not anticipated.

Soils RIA-1

The BHHRA evaluated risks to the future resident and indoor worker and current trespasser/recreational user, outdoor maintenance worker, and construction/utility worker and risks to exposed to soil within RIA-1. Although there are currently no residents or recreational facilities within the MML boundaries, the BHHRA evaluated risk for a future situation where a residence or recreational building was constructed onsite without remediation to evaluate potential adverse effects.

The future resident scenario was evaluated for both a child and adult. A cancer risk of 3 in 10,000 and a dose of 68 millirem per year (mrem/yr) were calculated for the child future resident scenario.

The cancer risk due to MML Site contamination is five-fold greater than from child background sources, which was 0.6 in 10,000. The dose from MML Site contamination is four-fold greater than from background sources, which was 16 mrem/yr. For the future adult resident, an adult cancer risk of 10 in 10,000 and an adult dose of 82 mrem/yr were calculated. The cancer risk due to MML Site contamination is three-fold greater than from background sources, which was 3 in 10,000. The dose from MML Site contamination is five-fold greater than from background sources, which was 17 mrem/yr.

For the future adult indoor worker scenario, a cancer risk of 5 in 10,000 and a dose of 26 mrem/yr were calculated. The cancer risk due to MML Site contamination is seven-fold greater than from indoor worker background sources, which was 0.7 in 10,000. The dose from MML Site contamination is seven-fold greater than from indoor worker background sources, which was 4 mrem/yr.

The cancer risk and radiation doses presented above indicate that there is an unacceptable risk to the future resident and future indoor worker exposed to soil within RIA-1. The cancer risk and dose levels are primarily due to exposure of Ra-226 via external radiation.

The BHHRA concluded that risks to the current trespasser/recreational user, outdoor maintenance worker, and construction/utility worker were within an acceptable risk range and exhibited radiological doses equal to or less than background for soil exposure. Therefore, there are no current exposures that show unacceptable risk due to soil contact within RIA-1.

Soils RIA-2

RIA-2 was evaluated for soil exposure to the current trespasser/recreational user scenario only. The area is located on a slope of the MML and would not be a likely location for constructing a building, such as a residence or a recreational facility.

The soil radionuclide activity and uranium nugget activity together were determined to have an exposure point concentration that potentially posed a cancer risk greater than the risk range. The USACE conducted a pilot study in RIA-2 to test a radiological soil sorting technology to support the evaluation as a remedial alternative in the Feasibility Study. Contaminated soils were excavated from this area for use in the study. When the excavation was completed, the USACE performed a radiological final status survey of the soils remaining, in accordance with the *Multi-Agency Radiation Survey and Site Investigation Manual*. It concluded that Ra-226 in soils remaining were indistinguishable from background concentrations. The contaminated soils were disposed of offsite in a licensed/permitted facility and the excavation area was backfilled using certified clean soils. There is no longer an increased cancer risk or the potential for an elevated radiation dose with respect to FUSRAP wastes in RIA-2.

Soils RIA-3

RIA-3 was evaluated for risks to the future resident and indoor worker and current trespasser/recreational user, outdoor maintenance worker, and construction/utility worker. Although there are currently no residents or recreational facilities within the MML Site boundaries, the BHHRA evaluated risk for a future situation where a residence or recreational building was constructed onsite without remediation to evaluate potential adverse effects.

The future resident scenario was evaluated for the both a child and adult in RIA-3. A cancer risk of 3 in 10,000 and a dose of 80 mrem/yr were calculated for the future child resident scenario. The cancer risk due to MML Site contamination is five-fold greater than from background sources, which was 0.6 in 10,000. The dose from MML Site contamination is five-fold greater than from background sources, which was 16 mrem/yr. A cancer risk of 10 in 10,000 and a dose of 97 mrem/yr were calculated for the future adult resident scenario. The cancer risk due to MML Site contamination is three-fold greater than from background sources, which was 3 in 10,000. The dose from MML Site contamination is six-fold greater than from background sources, which was 17 mrem/yr.

For the future adult indoor worker scenario, a cancer risk of 3 in 10,000 and a dose of 15 mrem/yr were calculated. The cancer risk due to MML Site contamination is four-fold greater than from background sources, which was 0.7 in 10,000. The dose from MML Site contamination is four-fold greater than from background sources, which was 4 mrem/yr.

The cancer risk and radiation doses presented above indicate that there is an unacceptable risk to the future resident and future indoor worker exposed to soil within RIA-3. The cancer risk and dose levels primarily are from exposure of Ra-226 via external radiation.

The BHHRA concluded that risks to the current trespasser/recreational user, outdoor maintenance worker, and construction/utility worker were within an acceptable risk range and exhibited radiological doses equal to or less than background for soil exposure. Therefore, there are no current exposures that show unacceptable risk due to soil contact within RIA-3.

Groundwater RIA-4

RIA-4, which is Site-wide shallow groundwater, was evaluated as a future situation in which the future resident and future indoor worker would use shallow groundwater as a potable water source without treatment. Currently at MML the groundwater is not used for any purpose. Groundwater was also evaluated for the construction worker exposure in which the worker would come in contact with shallow groundwater during excavation activities.

The future residential scenario was evaluated for both a child and adult. A cancer risk of 4 in 10,000 and a dose of 5 mrem/yr were calculated for the child future resident scenario. The cancer risk due to MML Site contamination is four-fold greater than from background sources, which was 1 in 10,000. The dose from MML Site contamination is equivalent to the dose from background sources, which was 5 mrem/yr. A cancer risk of 30 in 10,000 and a dose of 15 mrem/yr were calculated for the future adult resident scenario. The cancer risk due to MML Site contamination is three-fold greater than from background sources, which was 9 in 10,000. The dose from MML Site contamination is equivalent to the dose from background sources, which was 15 mrem/yr.

The cancer risk presented above indicates that there is an elevated probability of cancer to the future resident. The primary contributor to the cancer risk is from inhalation of Ra-226 during showering with untreated groundwater. However, as explained in the risk assessment this risk may be overestimated. The radiological dose from exposure to MML Site groundwater was within the range of doses from the background sources, and less than USEPA MCLs, as shown in Section 3.3.

Risk to the indoor worker and construction/utility worker were determined to be within an acceptable risk range and exhibited doses equal to or less than background.

4.2 Screening Level Ecological Risk Assessment Results

The Screening Level Ecological Risk Assessment evaluation demonstrated that radionuclide activities in the surface water, sediment, and surface soil within the MML Site are negligible and are not hazardous to the fish, birds, mammals, amphibians, reptiles, and invertebrates within the Site. Therefore, there is no need for risk mitigation associated with ecological resources.

5.0 REMEDIAL ACTION OBJECTIVES AND PROPOSED CLEANUP LEVELS

Remedial action objectives (RAOs) are site-specific goals that are established based on the nature and extent of contamination, the resources that are potentially threatened, and the potential for human and environmental exposure. The primary general objectives for any remedial action considered at the Site are to: (1) prevent or mitigate release of FUSRAP waste to the surrounding environment; and (2) eliminate or minimize the risk or future risk to human health and the environment (USEPA 1988). The NCP requires that RAOs be established by specifying contaminants and media of concern, potential exposure pathways, and remediation goals (40 CFR 300.430(e)(2)(i)).

The sources of contamination identified for FUSRAP-related radionuclide contamination at the MML Site include uranium ore wastes (i.e., nuggets) and contaminated soils associated with the disposal of MSP soils within RIA-1 and RIA-3 of the MML. FUSRAP-related radionuclides of concern are U-238, U-235, and associated decay products, specifically Ra-226, which is the radionuclide of concern identified as the dominant contributor to risk and used as a surrogate for uranium in determining cleanup levels. The risk assessment identified exposure to ionizing radiation from contaminated soils as the predominant pathway for future harmful effects to human health. Therefore, a RAO was established for soils contaminated with FUSRAP wastes within the MML.

Since the risk assessment determined there was not a risk to terrestrial and aquatic health, no RAOs were developed in response to ecological receptors. The risk assessment also determined no risk from FUSRAP wastes were present in surface water or sediments of Bound Brook and no RAOs were established for it. Additionally, although groundwater contributed to the risk to human health at MML, its radionuclide activity is at or near background levels and below the National Primary Drinking Water Regulation’s MCLs. RAOs therefore are not necessary for groundwater.

Remedial actions that “clean up” hazardous substances at CERCLA sites must clean to levels set by risk or Applicable or Relevant and Appropriate Requirements (ARARs), which are federal environmental or state environmental or facility siting requirements that must be attained by a CERCLA remedial action. The most appropriate radiologically specific ARAR for contaminated soil at the MML is the New Jersey Remediation Standard for Radioactive Materials, promulgated in NJAC 7:28-12 (USACE 2019). This regulation establishes standards for the remediation of real property (including soil, groundwater, surface water, and sediment) contaminated by radioactive materials at sites located within the state. For MML soil remediation, the substantive requirements found in NJAC 7:28-12.8(a)(1) have been identified as ARARs for the MML. NJAC 7:28-12.8(a)(1) requires that a maximum total annual effective dose of 15 mrem/yr above background (which includes the sum of annual external gamma radiation dose and intake dose, including groundwater) be met for an unrestricted use remedial action, a limited use remedial action, or a restricted use remedial action. This ARAR applies to all alternatives consisting of some action evaluated in the Feasibility Study and establishes the remediation goals, which are the basis for the cleanup goals.

The site-specific RAO identified for MML FUSRAP-related radionuclides of concern (Ra-226, U-238, and U-235 decay chains), exposure pathways, and receptors is to prevent human exposure to FUSRAP-related radionuclides of concern by reducing the potential for a future total effective dose to equal or less than the remedial goal of 15 mrem/yr by eliminating exposure to soils with average radioactivity greater than the derived concentration guideline level (DCGL) proposed for the site, as follows:

What is a Derived Concentration Guideline Level (DCGL)?

A DCGL is synonymous with a site clean-up level, and is a radionuclide-specific derived concentration guideline limit used to guide clean-up of a site to meet the RAO.

- The DCGL applied to unrestricted land use is an average of 5 pCi/g of Ra-226 in soil above background for FUSRAP contaminants within a final status survey unit. This criterion accounts for the risk contribution from all site radionuclides of concern identified.
- Alternatively, the DCGL for land used for recreational purposes (restricted use) is an average of 15 pCi/g of Ra-226 above background in soil for FUSRAP contaminants within a final status survey unit. This criterion accounts for the risk contribution from all site radionuclides of concern as identified.

6.0 SUMMARY OF REMEDIAL ACTION ALTERNATIVES

The focus of the remedial actions is to meet the RAOs associated with residual radionuclides (uranium and decay products, specifically Ra-226) in RIA-1 and RIA-3.

Seven alternatives were evaluated for soil remediation:

- Alternative 1 – No Further Action;
- Alternative 2 – Limited Action using Land Use Controls for Restricted Use;
- Alternative 3a – Excavation and Offsite Disposal for Unrestricted and Restricted Use;
- Alternative 3b – Excavation and Offsite Disposal for Unrestricted Use;
- Alternative 4a – Excavation, Radiological Soil Sorting, and Offsite Disposal for Unrestricted and Restricted Use;
- Alternative 4b – Excavation, Radiological Soil Sorting, and Offsite Disposal for Unrestricted Use; and
- Alternative 5 – Excavation and Onsite Containment.

The development of these alternatives considers the fact that the onsite contaminated soil within RIA-2 was remediated during the pilot study.

6.1 Alternative 1 – No Further Action

Alternative 1 has been considered in accordance with the NCP (40 CFR 300.430(e)(6)) and is intended to provide a baseline comparison to the other alternatives. In this alternative, no further remediation would be performed and no land use controls would be used to prevent exposure to soils contaminated with FUSRAP materials. There is no capital or present-worth operation or maintenance costs involved with this alternative, since there would be no further action.

6.2 Alternative 2 – Limited Action using Land Use Controls for Restricted Use

Alternative 2 addresses the soil contamination, along with land use controls and periodic inspections of the installed controls. Contaminated soil would be left in place in RIA-1 and RIA-3 and no active remediation would be performed. The land use controls would include restricting Site activities that would disturb the soil at the Borough of Middlesex property through deed notices associated with the titles of the properties and installation of fencing around the perimeter of the entire MML Site. Inspections of the site would occur periodically and would include visual observations. These inspections would include visual observations and the recording of soil disturbance activities, erosion, or unauthorized use of the landfill property, which may indicate the potential for exposure of contaminants. In addition, a review of the MML Site would occur at least every 5 years to determine whether the remedy continues to be protective of human health and the environment, as required by CERCLA 121(c). The capital cost for this alternative is approximately $338,700. The periodic inspection cost was estimated to be $28,200 and the cost for each 5-year review and associated report was estimated to be $63,300. The 100-year present worth was estimated to be $1,749,200.

6.3 Alternative 3a – Excavation and Offsite Disposal for Unrestricted and Restricted Use

Alternative 3a involves excavation of the Middlesex Presbyterian Church property in areas where Ra-226 concentrations are higher than 5 pCi/g above background and the Borough of Middlesex property where Ra-226 concentrations are higher than 15 pCi/g above background. Removing soils at these concentrations would allow unrestricted use of the Middlesex Presbyterian Church but require restrictions on the use of the Borough property.

As part of the excavation, larger debris material (greater than 2 inches in diameter) would be separated, scanned for radiation, and returned to the excavation area if below the concentrations listed above. Excavated contaminated soils would be transported to a licensed/permitted disposal facility, and excavated areas would be backfilled with clean soil, with topsoil placed on top to support planting after construction. In order to accomplish the excavation and backfill tasks, access roads and staging areas for material and equipment storage would be required.

Since contamination will remain on the Borough of Middlesex property with concentrations greater than the unrestricted DCGL of 5 pCi/g above background, a land use control would be required for that area. The land use control would involve a deed notice and signage marking the area. The federal government would conduct periodic inspections to evaluate the effectiveness of the signage in preventing exposure of soil contaminants. These inspections would include visual observations and the recording of soil disturbance activities, erosion, or unauthorized use of the landfill property, which may indicate the potential for exposure of contaminants. Additionally, 5-year reviews would be conducted to determine whether the remedy continues to be protective of human health and the environment. The capital cost for this alternative is approximately $10,748,800 and the periodic costs for inspections and 5-year reviews was estimated to be $91,500. The 100-year present worth was estimated to be $12,159,300.

6.4 Alternative 3b – Excavation and Offsite Disposal for Unrestricted Use

Alternative 3b is similar to Alternative 3a except that it involves excavation of all areas where Ra-226 concentrations are higher than 5 pCi/g above background. Large debris segregation, disposal of soil at a licensed/permitted disposal facility, and clean soil backfill would occur under this alternative.

For this alternative, no contamination will remain on the property with concentrations higher than the unrestricted DCGL of 5 pCi/g above background; this would allow unrestricted use of both properties. As a result, land use controls and 5-year reviews would not be required. The capital cost for this alternative is approximately $17,671,400. Given that no periodic costs would be required, the 100-year present worth would be the same at $17,671,400.

6.5 Alternative 4a – Excavation, Radiological Soil Sorting, and Offsite Disposal for Unrestricted and Restricted Use

Alternative 4a is the same as Alternative 3a, with the addition of radiological soil sorting of excavated soil. Excavated soils will be screened, with large debris and soil with Ra-226 concentrations below cleanup levels removed for replacement in excavation areas. Soil with concentrations higher than cleanup levels will be disposed of at a licensed/permitted disposal facility and clean soil will be used to backfill excavated areas. Radiological soil sorting is included to reduce the quantity of soil that will need to be disposed of while still achieving the remedial goal of removing soils with concentrations higher than the concentrations listed above. The 2017 pilot study demonstrated that the volume of soil requiring offsite disposal could be reduced by 78 percent with radiological soil sorting.

Since soil with concentrations greater than the unrestricted DCGL of 5 pCi/g above background contamination will remain on the Borough of Middlesex property, a land use control would be required for that area. The land use control would involve a deed notice and signage marking the area. The federal government would conduct periodic inspections to evaluate the effectiveness of the signage in preventing exposure of soil contaminants. These inspections would include visual observations and the recording of soil disturbance activities, erosion, or unauthorized use of the landfill property, which may indicate the potential for exposure of contaminants. Additionally, 5-year reviews would be conducted to determine whether the remedy continues to be protective of human health and the environment. The capital cost for this alternative is approximately $7,337,300, and the periodic cost for inspections and 5-year reviews was estimated to be $91,500. The 100-year present worth was estimated to be $8,747,800.

6.6 Alternative 4b – Excavation, Radiological Soil Sorting, and Offsite Disposal for Unrestricted Use

Alternative 4b is the same as Alternative 3b with the addition of radiological soil sorting of excavated soil. Excavated soils will be screened, with large debris and soil with Ra-226 concentrations below cleanup levels removed for replacement in excavation areas. Soil with concentrations higher than cleanup levels will be disposed of at a licensed/permitted disposal facility and clean soil will be used to backfill excavated areas.

For this alternative, no contamination will remain on the property with concentrations higher than the unrestricted DCGL of 5 pCi/g above background. As a result, land use controls and 5-year reviews would not be required. The capital cost for this alternative is approximately $11,942,700. Given that no periodic costs would be required, the 100-year present worth would be the same at $11,942,700.

6.7 Alternative 5 – Excavation and Onsite Containment

Alternative 5 involves the excavation of contaminated material in the same areas that were designated in Alternatives 3a and 4a, but the material would remain onsite and consolidated under a cap. The excavated material would be placed on the surface of the landfill outside of the church property, capped with a clay liner, and planted. The excavated areas would be backfilled with clean material and planted, as well. The cap would be designed to be in compliance with the substantive design requirements of 40 CFR Part 258.60(a) of RCRA which was identified as an ARAR in the feasibility study. These requirements include a cover permeability of 1×10^{-5} cm/s or equal to natural subsoils present, whichever is less; an infiltration layer that contains a minimum of 18 inches of earthen material; and a minimum of 6 inches of earthen material that is capable of sustaining native plant growth.

Since contamination would remain on the property, land use controls would be required for the property. The cap would need to be inspected regularly, and 5-year reviews would need to be conducted to determine whether the remedy continued to be protective of human health and the environment. The capital cost for this alternative is approximately $10,104,800 and the periodic costs for inspections and 5-year reviews was estimated to be $119,200. The 100-year present worth was estimated to be $12,385,700.

7.0 EVALUATION OF ALTERNATIVES

Each alternative was evaluated during the Feasibility Study against seven of the nine criteria established by the NCP (40 CFR 300.430(e)(9)(iii)) and are summarized in this section. The last two criteria (State Acceptance and Community Acceptance), referred to as the Modifying Criteria, are discussed in Section 7.3 below.

The nine evaluation criteria for Superfund Remedial Activities are as follows:

- **Protection of Human Health and the Environment**
- **Compliance with ARARs**
- **Long-Term Effectiveness and Permanence**
- **Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment**
- **Short-term Effectiveness**
- **Implementability**
- **Cost**
- **State Acceptance**
- **Community Acceptance**

7.1 Threshold Criteria

Threshold criteria must be met for an alternative to be considered as a remedial alternative for a site.

7.1.1 Protection of Human Health and the Environment

This evaluation criterion addresses whether an alternative provides protection of human health and the environment and describes how exposure risks are eliminated, reduced, or controlled through treatment, engineering, or land use controls.

Alternative 1 does not provide protection of human health and the environment in the short term or long term because it does not reduce risk or exposure from contaminants in the soil. Alternative 1 also allows for the continued existence of exposure pathways and does not implement any land use controls.

Alternatives 2, 3a, 3b, 4a, 4b, and 5 would be considered protective of human health and the environment. Although no active remediation would occur under Alternative 2, protection in the short term could still be achieved through implementation of land use controls. Land use controls would also provide protection after other remedial activities were complete for Alternatives 3a, 4a, and 5.

Alternatives 3b and 4b would protect human health and the environment after the completion of remediation.

7.1.2 Compliance with ARARs

Compliance with ARARs evaluates whether the alternative meets the federal and state environmental statutes and regulations that have been determined to be applicable or relevant and appropriate to this remediation, or whether a waiver is justified under 40 CFR 300.430 (f)(1)(ii)(C).

Alternative 1 does not include any remediation; therefore, it cannot achieve compliance with cleanup levels. Alternative 2 would comply with the cleanup levels through the implementation of land use controls, which would reduce the potential for exposure to radiation sources. However, no portion of RIA-1 and RIA-3 could be used without restrictions under Alternative 2. Alternatives 3a, 4a, and 5 would comply with the cleanup levels through the excavation or capping of radiologically impacted soils requiring the implementation of land use controls for any areas with remaining contamination. Alternatives 3b and 4b would comply with the cleanup levels through the excavation of all soils exceeding cleanup levels. These alternatives would not require any land use controls, as all contaminated soil would be removed from the MML Site.

7.2 Primary Balancing Criteria

Primary Balancing Criteria identify major trade-offs among alternatives.

7.2.1 Long-Term Effectiveness and Permanence

This evaluation criterion refers to the ability of the alternative to protect human health and the environment over time, once cleanup levels have been met.

Alternative 1 does not provide long-term effectiveness or permanence, as contaminant concentrations in soil would remain the same over time. Alternative 2 may provide long-term effectiveness as long as land use controls are maintained. The remaining alternatives are much more protective in the long term than Alternatives 1 or 2.

Alternatives 3a, 3b, 4a, and 4b would offer a higher degree of long-term effectiveness and permanence through the removal of contaminated soils from the MML Site. Alternatives 3a and 4a would implement land use controls to reduce human and environmental exposure to remaining contamination in the areas owned by the Borough of Middlesex. Alternatives 3b and 4b would remove all contamination with concentrations above cleanup levels on the MML Site; therefore these alternatives would be the most effective in the long term. Alternative 5 would achieve long-term effectiveness through the capping of contaminated soils; however, the cap would require maintenance throughout its lifetime to ensure its functionality and comes with a higher risk of long-term effectiveness with regard to a potential failure of the cap.

7.2.2 Reduction in Toxicity, Mobility, or Volume through Treatment

This evaluation criterion refers to anticipated ability of the remedy to reduce the toxicity, mobility, or volume of the hazardous components present at the MML Site through treatment.

This evaluation criterion is not applicable to Alternatives 1 and 2. Neither of these alternatives involves treatment of the contamination onsite or a reduction in the toxicity, mobility, or volume of contamination. Alternatives 3a, 3b, 4a, 4b, and 5 do not involve treatment of contamination onsite, either.

7.2.3 Short-Term Effectiveness

This evaluation criterion addresses the impacts to the community and Site workers during the time it takes to complete the action. This criterion also includes an assessment of the relative timeframe required for the remedial action to achieve protection.

No changes in potential exposure to workers or negative impacts to the environment would occur under Alternative 1. Alternative 2 would cause minimal short-term exposure to trespassers and occupational workers involved in installing fencing or other land use controls onsite. Alternatives 3a, 3b, 4a, 4b, and 5 would have a slight increase in risk to workers during the remedial activities; however, these impacts would be mitigated by health and safety measures. Soil erosion controls would be put in place to prevent migration of contamination from MML Site soils to Bound Brook for these alternatives. Removal of trees and shrubs before excavation would cause a temporary loss of habitat for the few species that live onsite, though vegetation would be replanted after remediation and removal of vegetation would be kept to a minimum. Alternatives 3b and 4b are anticipated to have the greatest short-term impact due to worker exposure to the greatest volume of contaminated material being removed, but these impacts can be mitigated and are considered minimal.

7.2.4 Implementability

This evaluation criterion addresses the technical and administrative feasibility of an alternative, including the availability of material and services required for cleanup.

Alternative 1 involves no further action and is, therefore, the most easily implementable alternative.

Land use controls that would be implemented as part of Alternative 2 have been easily implemented in the past. Alternative 2 is slightly more difficult to implement than Alternative 1 due to the requirement that the Borough of Middlesex agree to the restrictions necessary to avoid future exposure to radioactivity exceeding the cleanup levels. Based on the land use restriction currently included in Borough of Middlesex Code, General Legislation, Chapter 252, Paragraph 4, USACE believes that the Borough of Middlesex implementing a deed notice is feasible.

Alternatives 3a, 3b, 4a, 4b, and 5 utilize typical construction methods, equipment, and personnel to complete the remediation and are proven methods for FUSRAP remediation. It is anticipated that Alternatives 4a and 4b may require additional testing to refine the radiological soil sorting process. Alternatives 3b and 4b may take longer to implement due to greater volumes of soil removed, but Alternatives 3a and 4a may require more time for land use control negotiations with the Borough. Alternative 5 may be difficult to implement in terms of installing a cap that also complies with requirements for remediation of the existing non-radiological waste onsite and for future closure requirements for the landfill. In addition, long-term maintenance of the cap would be required for Alternative 5. For these reasons, Alternative 5 is the least implementable alternative.

7.2.5 Cost

This evaluation criterion addresses the estimated capital and operation and maintenance costs of each alternative. Due to the inclusion of remediation alternatives with extended lifetimes (e.g. landfill cap maintenance and land use controls), costs were evaluated over a 100-year period using present value (PV) analysis. A longer period of time was not used because there was not a significant difference in cost beyond 100 years. As noted in A Guide to Developing and Documenting Cost Estimates During the Feasibility Study (EPA 540-R-00-0022000) approximately 99.9% of present value costs are usually represented within the first 100 years. Accordingly, the PV for this project did not significantly change after 100 years. Using 100 years ensures that enough money is there in perpetuity for O&M costs for alternatives with extended lifetimes. Cost estimates are expected to be accurate within a range of +50 to -30 percent. The estimated total costs are as follows:

- Alternative 1 is estimated to cost $0;
- Alternative 2 is estimated to cost $1,749,200;
- Alternative 3a is estimated to cost $12,159,300;
- Alternative 3b is estimated to cost $17,671,400;

- Alternative 4a is estimated to cost $8,747,800;
- Alternative 4b is estimated to cost $11,942,700;
- Alternative 5 is estimated to cost $12,385,700.

Alternatives 3a, 3b, 4a, 4b and 5 would have higher costs than Alternative 2. Of the higher cost alternatives, Alternatives 4a and 4b would be the lowest cost to the government.

7.3 Modifying Criteria

The modifying criteria are dependent on the comments received. A description of each follows:

7.3.1 State Acceptance

State Acceptance is the eighth criteria considered for alternative selection. This evaluation criterion considers whether the State agrees with the USACE's analyses and recommendations, as described in the Remedial Investigation, Feasibility Study, and Proposed Plan. The Draft Proposed Plan was provided to NJDEP on September 3, 2020. The NJDEP provided comments to the USACE on November 20, 2020 and requested consideration of Alternative 4b as the preferred alternative. Based on this input and consideration of the other criteria, USACE identified Alternative 4b as the preferred alternative.

7.3.2 Community Acceptance

Community Acceptance is the ninth criteria considered for alternative selection and is the only remaining criteria to evaluate for final remedy selection. This evaluation criterion considers whether the local community agrees with the USACE's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance. The public comment period will be no less than 30 days.

8.0 PREFERRED ALTERNATIVE

Based upon an evaluation of all alternatives, Alternative 4b (Excavation, Radiological Soil Sorting, and Offsite Disposal for Unrestricted Use) is recommended as the preferred alternative for the following reasons:

- The alternative will meet the RAO and ARARs as described in Section 5;
- The alternative will meet the threshold criteria of protection of human health and the environment and compliance with cleanup levels;
- The alternative will be effective in the long term because soils presenting a potential unacceptable risk from FUSRAP wastes will be removed from both properties;
- The alternative will produce a significant reduction in volume of contamination through the removal of the soils contaminated with FUSRAP waste; and
- The alternative has been proven to be highly implementable based on historical remediation projects and a successful pilot study demonstrating radiological soil sorting.

Figure 8-1 shows the excavation areas associated with this alternative as well as the locations of transportation routes, temporary storage areas, and work areas. Approximate depths of excavation based on previous sampling are listed within each excavation area. The approximate area where the radiological soil sorting would take place is also noted on Figure 8-1.

Radiological soil sorting is a resource recovery technology involved in this alternative and will reduce the volume of offsite soils needed to backfill excavation areas as well as the volume of soils contaminated with FUSRAP wastes removed from the MML Site. This process is illustrated on Figure 8-2. The radiological soil sorting will occur after the material sorting process removes any items larger than 2-inches (e.g. municipal waste such as refrigerators and glass bottles) that do not contain radioactive contamination and will allow appropriately sized material (e.g soil) to be passed through the radiological sorter. After mechanical removal of large items, soil will be passed thru the radiological sorter and separated into distinct piles material with Ra-226 concentrations higher and lower than 5 pCi/g above background. Periodic sampling will be conducted to ensure remedial goals are being met.

The pilot study completed in RIA-2 resulted in a soil volume reduction efficiency rate of approximately 78 percent and had a maximum sorting rate of 300 cubic yards per day. A rate of 350 cubic yards per day is assumed for full-scale operation with the implementation of this alternative, as efficiencies are expected with the large debris sorting process that could be improved. The planned excavation volume for this alternative is 21,290 CY. Based on the assumed segregation efficiency rate, approximately 3,790 cubic yards of the excavated soils would require transport and offsite disposal in a licensed/permitted facility. The remaining 17,500 cubic yards would be removed through size segregation and radiological sorting and then placed back in the excavation areas. Large materials would not be placed in areas less than 2 feet deep to allow for a minimum 2-foot layer of clean backfill. The estimated cost for this remediation is $11,942,700.

Clean backfill would be required for the MML Site to replace the volume of soils removed from the Site for offsite disposal. Clean backfill brought onsite would be required to meet the NJDEP's requirements for uncontaminated surface soil, as specified in NJAC 7:28-12 and NJAC 7:26E-1.4, in accordance with NJDEP's Fill Material Guidance for SRP Sites.

During construction, there would be a potential for short-term health risks for construction workers and surrounding residents due to the excavation of the contaminated soils. These risks will be mitigated by monitoring the air for dust and using dust suppression techniques (e.g., wetting the soils) to reduce the amount of dust created during excavation.

Land use controls for FUSRAP contamination would not be necessary under this alternative due to the removal of FUSRAP-related contamination that allows for unlimited use and unrestricted exposure. Additional actions post-remediation, such as site inspections and CERCLA 5-year reviews and reporting, would not be required for this alternative from a FUSRAP perspective. It should be noted that the use of the property is currently restricted by Borough of Middlesex Code, General Legislation, Chapter 252, Paragraph 4 which states "that the former landfill site [MML] be protected from being used as a residential or commercial property and that the site be reserved for and used only for both active and passive recreational uses and parking requirements associated therewith."

Based on information currently available, the preferred alternative meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria. The USACE expects the preferred alternative to satisfy the following statutory requirements of CERCLA §121(b): (1) be protective of human health and the environment; (2) comply with ARARs; (3) be cost-effective; and (4) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.

The preferred alternative can change in response to public comment or new information.

9.0 COMMUNITY PARTICIPATION

The USACE requests and encourages public input to ensure that the remedy selected for soils contaminated with FUSRAP material at the MML Site addresses the concerns and meets the needs of the local community. While this Proposed Plan makes a recommendation for soil remediation, the actual remedy will not be selected until all comments have been received and reviewed by the USACE, in coordination with the NJDEP.

Written comments about the Proposed Plan will be accepted after a Public Notice is published in local newspapers, on the USACE website (https://www.nan.usace.army.mil/Media/Fact-Sheets/Fact-Sheet-Article-View/Article/563012/fact-sheet-middlesex-municipal-landfill/), and by letter to stakeholders. The public comment period will run from August 2, 2021, through September 3, 2021. Upon timely request (before the end of the comment period), the comment period will be extended for an additional 30 days. During the comment period, a public meeting will be held virtually to present the conclusions of the Remedial Investigation and Feasibility Study, elaborate further on the reasons for recommending the preferred alternative, and receive public comments. These documents are available for review on the USACE website at the web address above. The public meeting will be held online as a result of current restrictions for public gatherings resulting from the COVID-19 pandemic. A link to access the virtual public meeting will be provided in the Public Notice.

Written comments will be accepted any time during the comment period and should be sent to:

Ms. Helen Edge
U.S. Army Corps of Engineers, New York District
26 Federal Plaza, Room 1811
New York, New York 10278-0090
(917) 790-8333

The USACE will evaluate comments submitted during the comment period, with responses to significant public comments formally documented in a Responsiveness Summary. After considering all comments, the USACE, in coordination with the NJDEP, will make a final decision regarding the remediation for the MML Site. The final decision will be detailed in a Record of Decision, which will include the Responsiveness Summary. The Record of Decision will be incorporated into the Administrative Record for the MML Site, which is available for review online (see above link) and at the Middlesex Public Library, although access to the files may be limited as a result of restrictions during the current pandemic. The Middlesex Public Library is located at:

Middlesex Public Library
1300 Mountain Avenue
Middlesex, New Jersey 08846

Business Hours:
Monday and Wednesday, 11 AM to 8 PM
Tuesday and Thursday, 1 PM to 9 PM
Friday, 10 AM to 5 PM
Saturday, 10 AM to 2 PM
Sunday, Closed

10.0 REFERENCES

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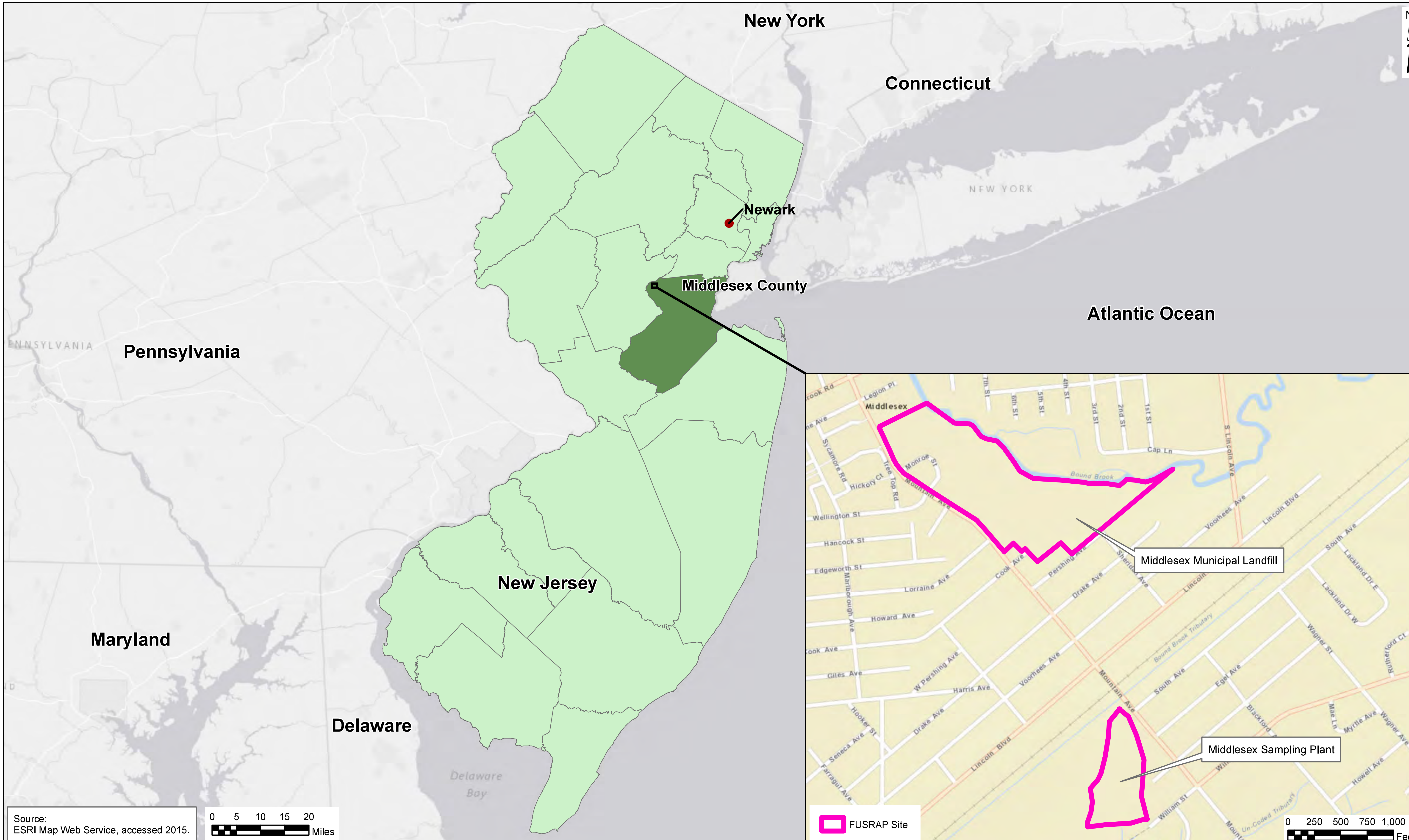
FIGURES



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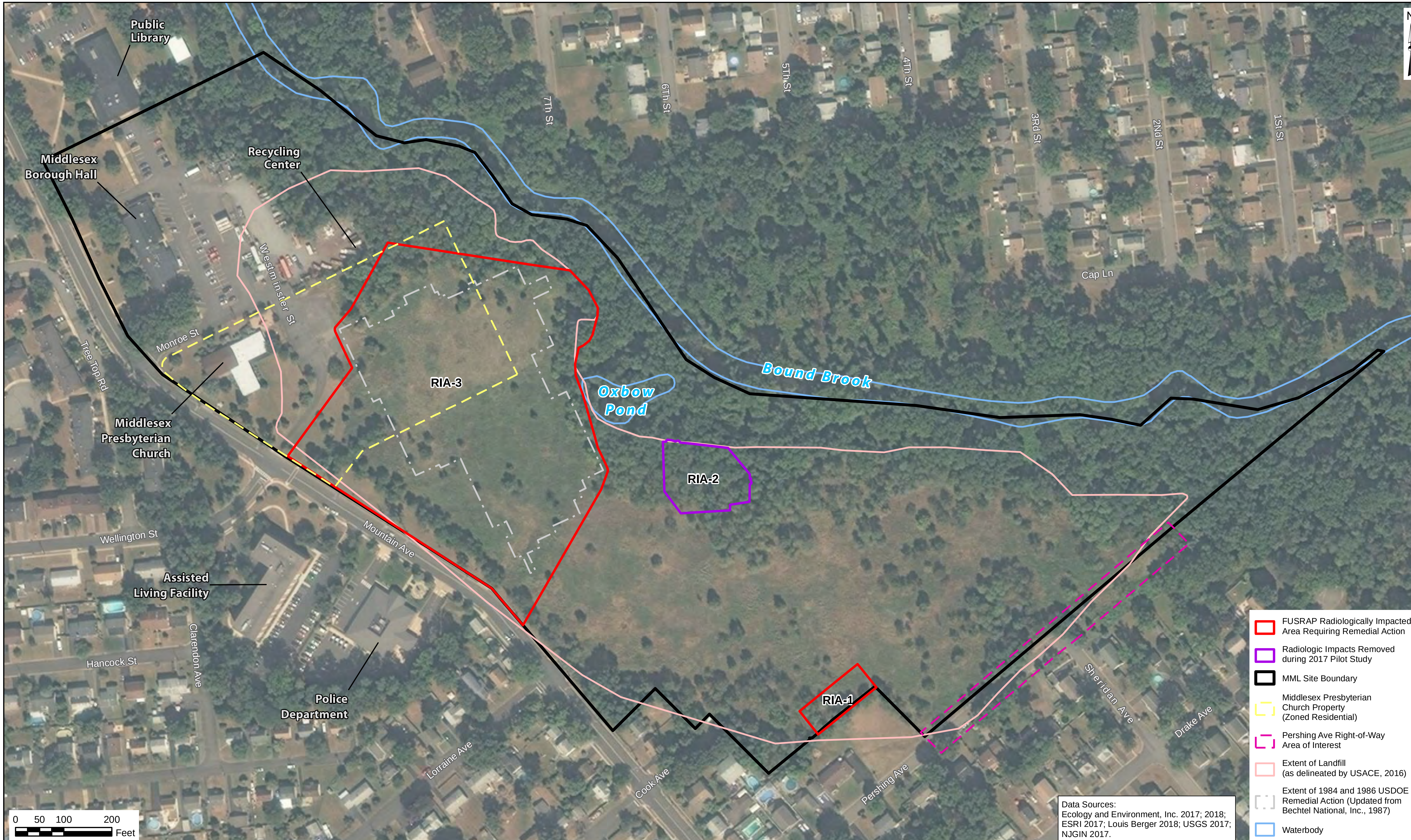
Middlesex Municipal Landfill - Regional Map

Middlesex Municipal Landfill FUSRAP Site, Borough of Middlesex, New Jersey

2018
Figure 1-1



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Radiologically Impacted Areas (RIAs) at MML

Middlesex Municipal Landfill FUSRAP Site, Borough of Middlesex, New Jersey

Figure 1-2

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Radium-226 Sample Results for RIA-1

Middlesex Municipal Landfill FUSRAP Site, Borough of Middlesex, New Jersey

Figure 3-1

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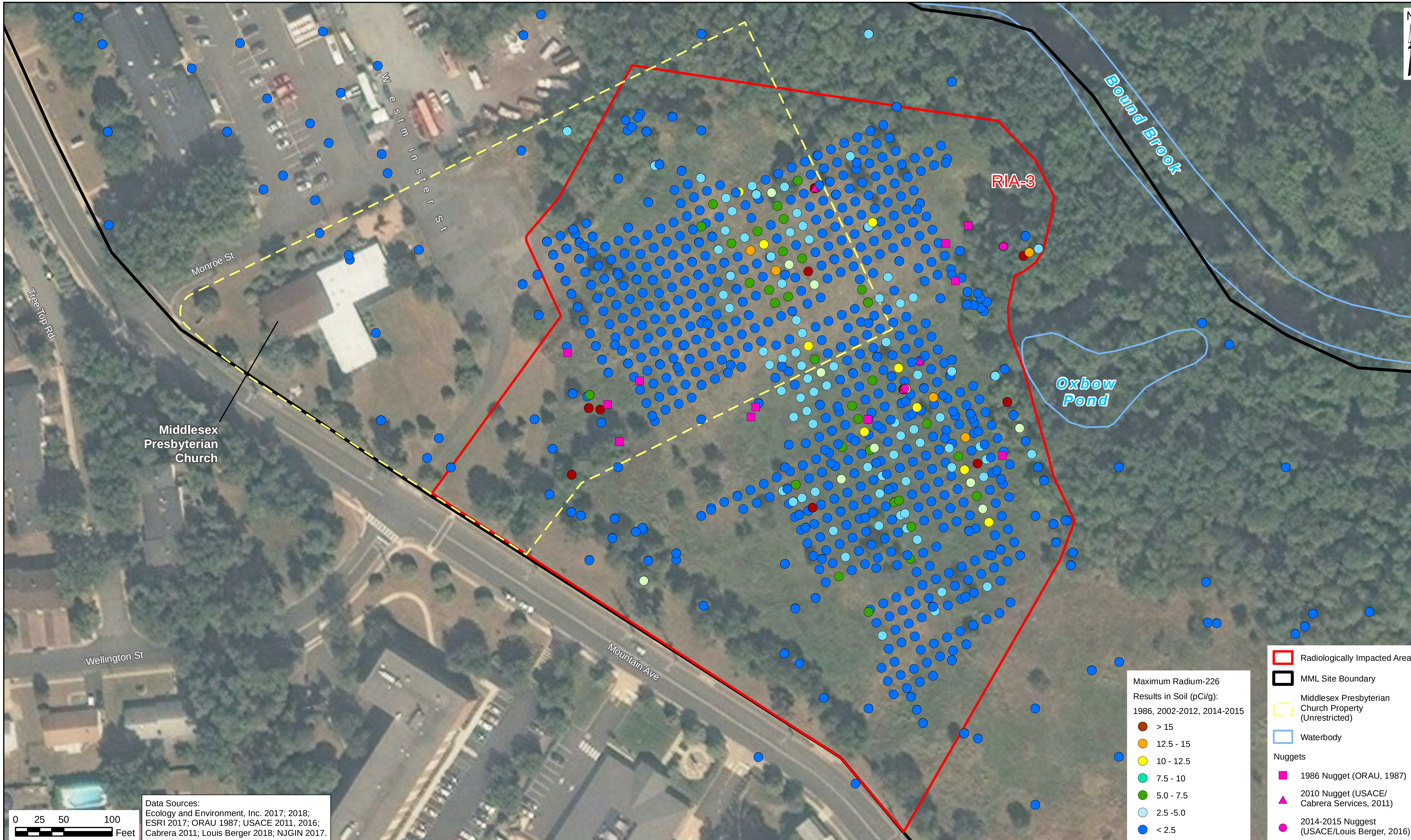

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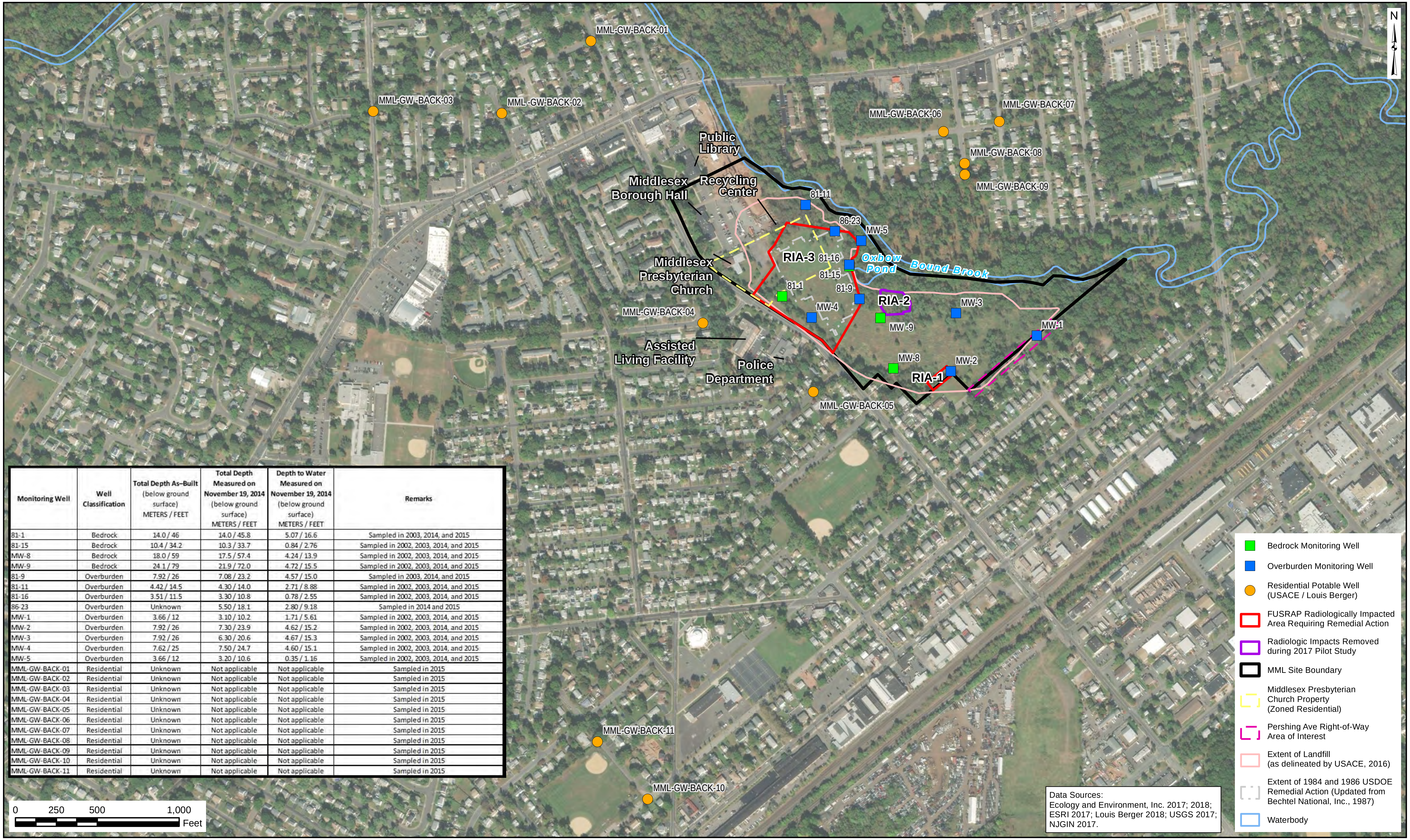
Radium-226 Sample Results for RIA-3

Middlesex Municipal Landfill FUSRAP Site, Borough of Middlesex, New Jersey

Figure 3-2



Monitoring Well	Well Classification	Total Depth As-Built (below ground surface) METERS / FEET	Total Depth Measured on November 19, 2014 (below ground surface) METERS / FEET	Depth to Water Measured on November 19, 2014 (below ground surface) METERS / FEET	Remarks
81-1	Bedrock	14.0 / 46	14.0 / 45.8	5.07 / 16.6	Sampled in 2003, 2014, and 2015
81-15	Bedrock	10.4 / 34.2	10.3 / 33.7	0.84 / 2.76	Sampled in 2002, 2003, 2014, and 2015
MW-8	Bedrock	18.0 / 59	17.5 / 57.4	4.24 / 13.9	Sampled in 2002, 2003, 2014, and 2015
MW-9	Bedrock	24.1 / 79	21.9 / 72.0	4.72 / 15.5	Sampled in 2002, 2003, 2014, and 2015
81-9	Overburden	7.92 / 26	7.08 / 23.2	4.57 / 15.0	Sampled in 2003, 2014, and 2015
81-11	Overburden	4.42 / 14.5	4.30 / 14.0	2.71 / 8.88	Sampled in 2002, 2003, 2014, and 2015
81-16	Overburden	3.51 / 11.5	3.30 / 10.8	0.78 / 2.55	Sampled in 2002, 2003, 2014, and 2015
86-23	Overburden	Unknown	5.50 / 18.1	2.80 / 9.18	Sampled in 2014 and 2015
MW-1	Overburden	3.66 / 12	3.10 / 10.2	1.71 / 5.61	Sampled in 2002, 2003, 2014, and 2015
MW-2	Overburden	7.92 / 26	7.30 / 23.9	4.62 / 15.2	Sampled in 2002, 2003, 2014, and 2015
MW-3	Overburden	7.92 / 26	6.30 / 20.6	4.67 / 15.3	Sampled in 2002, 2003, 2014, and 2015
MW-4	Overburden	7.62 / 25	7.50 / 24.7	4.60 / 15.1	Sampled in 2002, 2003, 2014, and 2015
MW-5	Overburden	3.66 / 12	3.20 / 10.6	0.35 / 1.16	Sampled in 2002, 2003, 2014, and 2015
MML-GW-BACK-01	Residential	Unknown	Not applicable	Not applicable	Sampled in 2015
MML-GW-BACK-02	Residential	Unknown	Not applicable	Not applicable	Sampled in 2015
MML-GW-BACK-03	Residential	Unknown	Not applicable	Not applicable	Sampled in 2015
MML-GW-BACK-04	Residential	Unknown	Not applicable	Not applicable	Sampled in 2015
MML-GW-BACK-05	Residential	Unknown	Not applicable	Not applicable	Sampled in 2015
MML-GW-BACK-06	Residential	Unknown	Not applicable	Not applicable	Sampled in 2015
MML-GW-BACK-07	Residential	Unknown	Not applicable	Not applicable	Sampled in 2015
MML-GW-BACK-08	Residential	Unknown	Not applicable	Not applicable	Sampled in 2015
MML-GW-BACK-09	Residential	Unknown	Not applicable	Not applicable	Sampled in 2015
MML-GW-BACK-10	Residential	Unknown	Not applicable	Not applicable	Sampled in 2015
MML-GW-BACK-11	Residential	Unknown	Not applicable	Not applicable	Sampled in 2015

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Groundwater Monitoring Wells and Potable Wells Sampled for the RI

Middlesex Municipal Landfill FUSRAP Site, Borough of Middlesex, New Jersey

Figure 3-3

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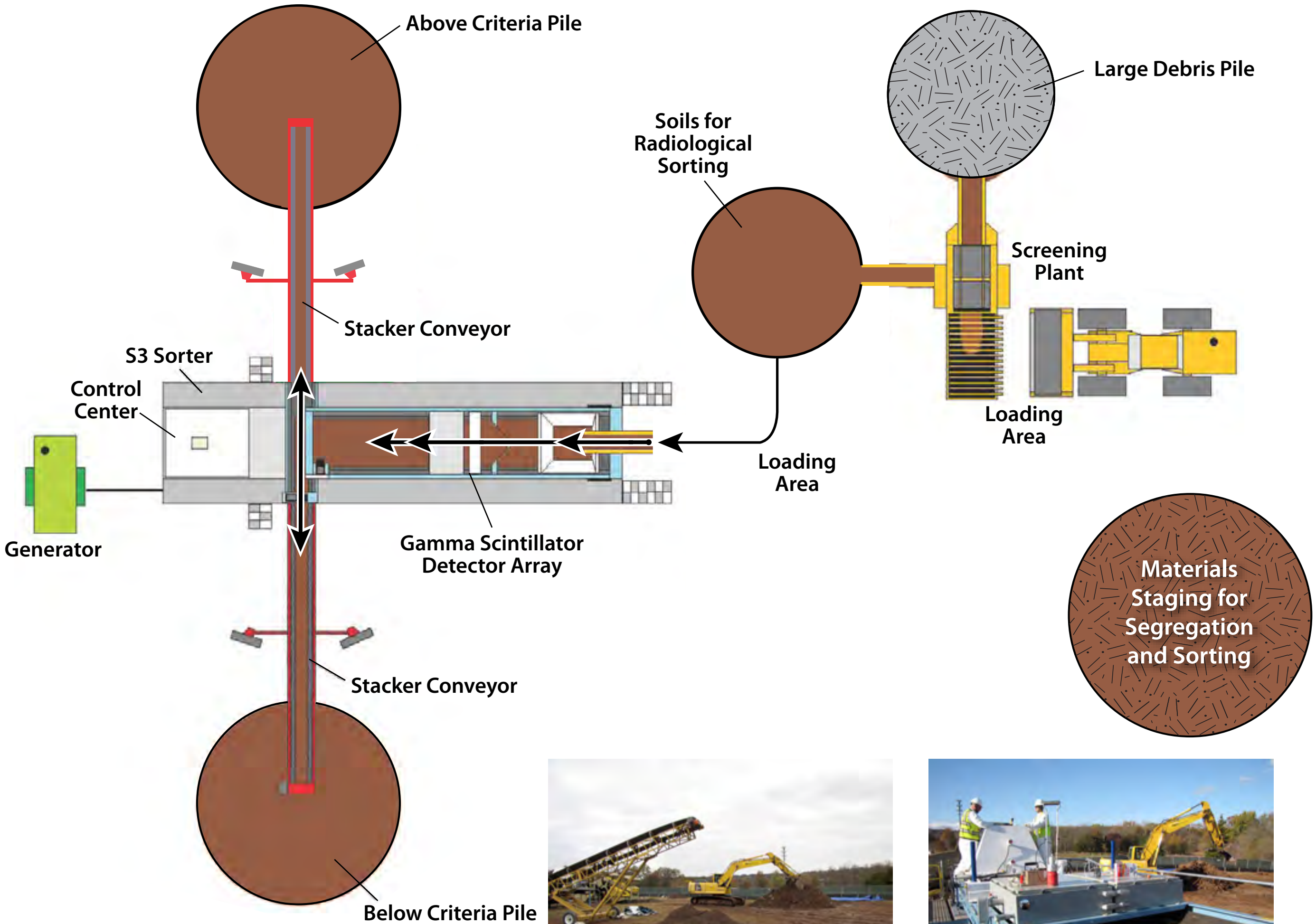
Preferred Alternative: Alternative 4b – Excavation with Soil Sorting for Unrestricted Use

Middlesex Municipal Landfill FUSRAP Site, Borough of Middlesex, New Jersey

Figure 8-1



Photos shown were taken during the 2017 Soil Sorting Pilot Study

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Soil Sorter Process Layout

Middlesex Municipal Landfill FUSRAP Site, Borough of Middlesex, New Jersey

2018

Figure 8-2