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## LIST OF ACRONYMS AND ABBREVIATIONS

AE ..... Architect-Engineer
ANL ..... Argonne National Laboratories
BRAC ..... Base Realignment and Closure
bgs ..... below ground surface
CCME ..... Canadian Council of Ministers of the Environment
COPC ..... Chemicals of Potential Concern
CSM ..... Conceptual Site Model
COPECs ..... Constituents of Potential Ecological Concern
DQOs ..... Data Quality Objectives
DO ..... Dissolved Oxygen
ERA ..... Ecological Risk Assessment
ESLs ..... Ecological Screening Levels
EPC ..... Exposure Point Concentrations
FED MCLs ..... Federal Maximum Contaminant Levels
GPS ..... Global Positioning System
HHRA ..... Human Health Risk Assessment
ICFKE ..... ICF Kaiser Engineers
ISQG ..... Interim Sediment Quality Guidance
ITRC ..... Interstate Technology Regulatory Council
LOC ..... Level of Concern
MCLG ..... Maximum Contaminant Level Goal
µg/L ..... micrograms per liter
mg/kg ..... milligrams per kilogram
NSSF ..... National Sports Shooting Foundation
NJDEP ..... New Jersey Department of Environmental Protection
NJDEP ER-Ls ... NJDEP Effects Range-Low
NJGWQC ..... NJDEP Groundwater Quality Criteria
NJ MCLs ..... New Jersey Maximum Contaminant Levels
NJSWQC ..... New Jersey Surface Water Quality Criteria
NYSDEC ..... New York State Department of Environmental Conservation
NFA ..... No Further Action
NRDCSRS ..... Non-Residential Direct Contact Soil Remediation Standards
ORP ..... Oxidation-Reduction Potential
PEF ..... Particulate Emission Factor
PTA ..... Picatinny Arsenal
PAH ..... Polynuclear Aromatic Hydrocarbons
ORNL ..... Oak Ridge National Laboratory
QAPP ..... Quality Assurance Project Plan
QA/QC ..... Quality Assurance/Quality Control
RME ..... Reasonable Maximum Exposures
RSL ..... Regional Screening Levels
RA ..... Risk Assessment
RAGS ..... Risk Assessment Guidance for Superfund
RBCs ..... Risk-Based Concentrations
RI ..... Remedial Investigation
RIR ..... Remedial Investigation Report
RBC ..... Risk-Based Concentration
SL ..... Screening Level
SLERA ..... Screening Level Ecological Risk Assessment
SQB ..... Sediment Quality Benchmark
Shaw ..... Shaw Environmental and Infrastructure
TW ..... Tapwater
TAL ..... Target Analyte List

TOC ..... Total Organic Carbon
UXO ..... Unexploded Ordnance
USACE ..... United States Army Corps of Engineers
USEPA..... United States Environmental Protection Agency
USFWS..... United States Fish and Wildlife Service
UCL..... Upper Confidence Limit
VI..... Vapor Intrusion
VDEQ..... Virginia Department of Environmental Quality
VOCs ..... Volatile Organic Compounds
VF ..... Volatilization Factor

# 1.0 INTRODUCTION

The United States Army Corps of Engineers (USACE) has tasked Shaw Environmental & Infrastructure (Shaw) to perform a Remedial Investigation (RI) of the former Skeet Range located to the north of Site 180 at Picatinny Arsenal (PTA), Dover, New Jersey. Site 180 is located at the southern end of PTA on the eastern side of Green Pond Brook (**Figure 1**). The RI work order will be performed under the Architect-Engineer (AE) contract number W912DR-05-D-0026, Task Order 04.

The former Skeet Range RI is being conducted because soil and sediment sampling from 2002 through 2010 indicated lead and polynuclear aromatic hydrocarbon (PAH) contamination in and around the former Skeet Range. The investigation will focus on the nature and extent of contaminants to assess the risk for future land uses. The investigation will also further monitor groundwater and surface water in the area to ensure elevated concentrations of lead and/or PAHs do not leach into surrounding surface water bodies or the underlying aquifer. The proposed sampling in this investigation is expected to characterize the nature of contamination related to past activities at the former Skeet Range. The RI Work Plan provides a summary of the site description, site history/background, and previous sampling results. The RI Work Plan proposes additional groundwater, surface water, soil, and sediment sampling for various analytical parameters. **Section 2.0** presents a detailed history of the former Skeet Range and Site 180, including a summary of historical analytical results. **Section 3.0** presents the problem statement, data needs, and data quality objectives (DQOs) for the proposed scope of work. **Section 4.0** presents a detailed scope of work for the RI. **Section 5.0** presents the methodologies for the risk assessment (RA) to be performed as part of the RI. **Section 6.0** states the reporting procedures for the RI results. **Section 7.0** provides references for this RI Work Plan.

## 2.0 FORMER SKEET RANGE AND SITE 180 BACKGROUND

The former Skeet Range is located approximately 150 feet northwest of Site 180 on the southern end of PTA on the eastern side of Green Pond Brook. The former Skeet Range is bounded by Site 19 to the north-northwest, Site 180 to the south and southeast, Site 34 to the southwest, and the Green Pond Brook to the west (**Figure 1**). Large portions of the southern end of PTA were subject to landfilling to increase the amount of usable land. A review of aerial photography confirmed that extensive landfilling activities occurred in this area including Site 180 and the Skeet Range.

Portions of PTA's land have been classified as wetlands. This includes portions of the former Skeet Range. Wetlands encompass approximately 1,250 acres of the 5,853 acres at PTA. Wetlands at PTA include forested wetlands and shrub lands. Approximately 92% of the wetlands are maple swamp forest, lakes and ponds, and their associated woody scrub-shrub wetlands. The largest portion of wetlands is located within the southern portion of PTA, which includes the former Skeet Range. This is an area described as being laced with drainage ditches. Hydric soils comprise 26% of PTA's land. Approximately 50% of the former Skeet Range consists of hydric soils. The entire former Skeet Range has been mapped as NJDEP wetlands (USAEC, 2001). Refer to **Figure 9** for a map of the wetland areas and soils within and around the former Skeet Range.

The range was constructed in the 1950s and was used for recreational trap and skeet shooting into the 1990s. The range consists of three buildings - 1181, 1182 and 1181A – and several asphalt walkways through an open grassy area where the shooting occurs. As part of the Phase I RI, a detailed site inspection was conducted of the range (Dames and Moore, 1995). At the time, Buildings 1181 and 1182 were used to launch the traps and to store cases of targets. Building 1181A contained several barbeque grills and site maintenance equipment such as a wheelbarrow, rakes and plywood. The shooters faced north and shot towards a heavily wooded area. Dames and Moore noted that the range contained accumulated bulk lead shot and clay fragments from the historical use of the range. There was concern that the accumulated lead shot may represent an ecological concern. However, no further investigation was recommended due to the ongoing activities at the range.

From 1991 to 2007, Site 180 was investigated which included the northeastern push-out boundary toward the area of the Skeet Range. Buried debris was found along this push-out boundary in 2005 and subsequently additional environmental sampling and debris removal were performed. After sampling from 2005 to 2007, ARCADIS issued a letter to the Army suggesting that the lead identified in Sample 180SS-15 is outside the boundary of Site 180, is related to the historical use of the Skeet Range, and therefore should be addressed as a separate site (**Figure 2**). Thus, the Army agreed to further investigate the lead contamination to identify the potential source of the elevated lead levels.

Analytical results from soil, sediment, and surface water sampling, performed in June 2008 by Shaw, indicated several surface soil samples exceeded the soil level of concern (LOC) for lead (Shaw, 2008). A subsurface soil sample collected in the area also contained a lead concentration above the soil LOC. Furthermore, sediment and surface water samples collected from a drainage ditch in the area revealed concentrations of lead above the sediment and surface water LOCs. Previous surface soil sampling in the area performed by IT Corporation in October 2002 also found elevated concentrations of PAHs above applicable LOCs in the area of the former Skeet Range (Shaw, 2004).

As a result of the 2008 investigation findings and in response to regulatory comments regarding findings during previous investigations in the area, Shaw performed additional investigation within and around the former Skeet Range impact fan to further characterize impacts from lead concentrations in soil and sediment, to evaluate levels of PAHs in the soil and sediment, and evaluate metals and PAH concentrations in shallow groundwater (Shaw, 2010a).

Based on the results of the 2010 investigation of the former Skeet Range, Shaw developed this RI Work Plan to delineate the extent of contamination and characterize the risks posed by the contamination. The following sections provide greater detail of the existing site data.

Please note the term LOC for all media in this work plan refers to pre-determined values for Picatinny Arsenal based on certain sets of criteria dependent on the media being analyzed. For groundwater, the LOC is determined by taking the lowest of the New Jersey Department of Environmental

Protection (NJDEP) Groundwater Quality Criteria (NJGWQC) (NJDEP, 2010a), Federal [United States Environmental Protection Agency (USEPA)] maximum contaminant levels (MCLs) (USEPA, 2009a), NJDEP MCLs (NJ MCLs) (NJDEP, 2004), and any non-zero Federal (USEPA) maximum contaminant level goal (MCLG). If these are not available, then the LOC becomes the lowest of the USEPA Region 2 Regional Screening Level (RSL) Tapwater (TW) Risk-Based Concentrations (RBCs) (USEPA, 2010a) and USEPA Federal Drinking Water Health Advisories (USEPA, 2009b).

For soil, the LOC is determined by first using the NJDEP Non-Residential Direct Contact Soil Remediation Standard (NRDCSRS) (NJDEP, 2009). If a NJDEP NRDCSRS is not available, the USEPA Industrial Direct Contact Screening Level (SL) is used. After one of these values is selected, it is compared to the Picatinny Arsenal background value (if available) (IT, 2002) and the higher number is the LOC.

For sediment, the LOC is determined by taking the lowest of the Canadian Council of Minister of the Environment (CCME) Interim Sediment Quality Guideline (ISQG) (CCME, 2003), New York State Department of Environmental Conservation (NYSDEC) Sediment Criteria (NYSDEC, 1999), Oak Ridge National Laboratory (ORNL) Sediment Quality Benchmark (SQB) (ORNL, 1997), or NJDEP Effects Range-Low values (NJDEP ER-Ls) (NJDEP, 2010b). If these are not available, the USEPA Industrial Direct Contact SL is used. After this value is determined, it is compared to Picatinny Arsenal background value (if available) (IT, 2002) and the higher number is the LOC.

For surface water, the LOC is the New Jersey Surface Water Quality Criteria (NJSWQC) (NJDEP, 2010c), if available. If this is not available, the lower value of the USEPA Ecological Screening Levels (ESLs) and USEPA Human Health Risk for Consumption (HHRC) values (USEPA, 2009c) is used. If these two are also not available, then the USEPA RSL TW RBC is used. After one of these values is selected, it is compared to Picatinny Arsenal background value (if available) (IT, 2002) and the higher number is the LOC.

## 2.1 EXISTING SITE DATA

Several investigations have been performed within and around the former Skeet Range. The following sections present an overview of the findings of these investigations.

### 2.1.1 Historical Site 180 Investigation Results

In 1991, the Site 180 boundaries were defined by Argonne National Laboratories (ANL) as a 300 foot by 300 foot area (ANL, 1991); however, these boundaries did not correlate with any physical or natural features. The original Site 180 included several piles of debris containing railroad ties, concrete rubble, scrap metal and tires (Dames and Moore, 1998). The lateral extent of Site 180 has been increased since the completion of the Phase I RI Report to include additional piles of debris and waste material in the vicinity of the original site. During an investigation of Site 180 in October 2002, two surface soil samples were collected within the former Skeet Range (Shaw, 2004). Refer to Section 2.1.3.1 below for additional discussion of this investigation. On November 1, 2005 during an Army tour of the site with the regulators, NJDEP, USEPA and United States Fish and Wildlife Service (USFWS) representatives expressed concern over the potential contamination and risk associated with buried debris identified along the boundary of Site 180. In November 2005, 12 surface soil samples were collected along the push-out boundary between Site 180 and the marsh. All samples were located near partially buried debris including some drums. The drums were in poor condition and decomposed by rust. Sample 180SS-15A located at the northeastern end of Site 180 exceeded the sediment LOCs for cadmium, copper, lead, mercury, nickel, zinc and several PAHs. Subsequent to the sampling event, all of the drum remnants and other surface debris were removed and disposed by Shaw in 2006. Additional delineation sampling was conducted around (Samples 180SS-15N, S, E, W) and beneath (Sample 180SS-15B) Sample 180SS-15A in March 2006. Lead levels exceeded the sediment LOC of 38.8 milligrams per kilogram (mg/kg) in all five samples with concentrations ranging from 293 mg/kg to 2,830 mg/kg (**Figure 2**).

In February 2007, ARCADIS issued a letter to the Army suggesting that the lead identified in Sample 180SS-15 is outside the boundary of Site 180, is related to the historical use of the adjacent Skeet Range, and therefore should be addressed as a separate site. **Figure 2** shows that the 180SS-15 soil samples were collected approximately 400 feet from the shooting pad of the former range and within

the maximum shot fall zone for trap and skeet ranges of 375 feet to 600 feet from the firing line (ITRC, 2005; NSSF, 1997). Thus, the Army agreed to further investigate the lead contamination to identify the potential source of the elevated lead levels.

### 2.1.2 Historical Site 19 and Green Pond Brook Investigation Results

In order to assess the lead contamination identified during the Site 180 investigation, data from other sites in proximity to Site 180 and the former Skeet Range were reviewed. The two sites that were evaluated are Site 19 and Green Pond Brook (**Figure 1**).

In 1993 as part of the Phase I RI at Site 19, five surface soil, five subsurface soil, one surface water, one sediment, and 11 groundwater samples from four monitoring wells were collected. PAHs and metals were detected in the soil samples. The PAH concentrations did not exceed the comparison criteria and are believed to be related to the telephone poles stockpiled in the area or open burning activities at Site 34. The PAHs are unlikely to be associated with the skeet targets due to the distance from the range and the trap house. Metals exceedances were reported for arsenic and beryllium. The maximum lead concentration in the ten samples was 43.2 mg/kg (Dames and Moore, 1998).

The surface water and sediment samples were collected from an area of intermittent ponded water at the center of the site and not one of the drainage channels that traverse the area. PAHs and lead were detected in the surface water sample. The PAH and lead concentrations identified in the sediment sample were below the appropriate comparison criteria used at that time, the ER-L and ER-M sediment concentrations as outlined in a National Oceanic and Atmospheric Administration technical memorandum dated August 1991.

Arsenic and lead were detected above the comparison criteria in the unfiltered groundwater samples collected from the site wells and one upgradient well (C-1B). Arsenic concentrations ranged up to 13.8 micrograms per liter [(µg/L); LOC = 3 µg/L] and lead concentrations ranged up to 32.9 µg/L (LOC = 5 µg/L). Arsenic concentrations in filtered groundwater samples also exceeded the LOC; however, lead was not detected in the filtered samples at a detection limit of 5 µg/L.

One surface water sample and one sediment sample were collected from Green Pond Brook upgradient of the former Skeet Range and the associated impact fan. Sample SW/SDGP-16 was collected at the intersection of South Brook Road and Shinkle Road. The surface water sample did not contain detectable levels of PAHs or lead. The sediment sample contained elevated levels of several PAHs and a lead concentration of 1,250 mg/kg. Several surface water and sediment samples have been collected from Green Pond Brook downgradient of the former range adjacent to Site 34. Similar concentrations of lead and PAHs were detected in the downgradient sediment samples. It is unclear whether the elevated PAHs and lead concentrations in the sediment are related to open burning activities at Site 34, fill used in this marshy portion of the base, former activities at the Skeet Range or base operations upgradient of this area.

### 2.1.3 Historical Skeet Range Investigation Results

#### 2.1.3.1 October 2002 Investigation

In October 2002, IT Corporation collected seven surface soil samples (34SS-24 through 34SS-30) as part of an investigation of Sites 34 and 180 (Shaw, 2004). Samples 34SS-29 and 34SS-30, collected at the Skeet Range, were the only samples collected at the range prior to Shaw's investigations. The samples were analyzed for PAHs and Target Analyte List (TAL) Metals. Lead concentrations in the two samples were well below the LOC of 600 mg/kg (the LOC at the time of this 2002 investigation) with levels of 13.1 mg/kg and 76.7 mg/kg. The only LOC exceedances reported in the two samples were arsenic and PAHs. Sample 34SS-29, located upgradient of the actual range had an arsenic concentration of 38.8 mg/kg (LOC = 20 mg/kg). Sample 34SS-30, located within the firing zone of the Skeet Range, had an arsenic concentration of 25.6 mg/kg. The arsenic contamination may be related to runoff from Site 34, Site 180 or the Skeet Range. Seven PAHs were detected in excess of their respective LOCs in Sample 34SS-30. The LOC exceedances ranged from 17 mg/kg for dibenz(a,h)anthracene (LOC = 0.66 mg/kg) to 94 mg/kg for chrysene (LOC = 40 mg/kg). The benzo(a)pyrene concentration of 90 mg/kg exceeded the LOC of 0.66 mg/kg by more than two orders of

magnitude. The elevated PAH levels are most likely the result of the clay targets used at the Skeet Range (Shaw, 2004).

#### 2.1.3.2 2007 and 2008 Investigation

In July 2007, Shaw personnel performed a site walk-over in preparation of future investigations and observed similar findings to Dames and Moore site inspection. Most of the surface debris was clay fragments and spent shells.

In order to determine the source and extent of the lead contamination, a sampling approach was developed based on guidance documents from the NJDEP (NJDEP, 2005a,b), the Interstate Technical Regulatory Council (ITRC, 2003; ITRC, 2005); and the National Sports Shooting Foundation (NSSF, 1997). Guidance was also provided by the U.S. Army Environmental Center. As part of the Lead Investigation Report by Shaw in 2008, surface soil samples were collected every 50 feet from previous sample locations 180SS-15N,S,E,W up to 200 feet from the original sample. A subsurface soil sample (180SS-E/C) was collected from 2.0 to 2.5 feet below ground surface (bgs) at former sample location 180SS-15E, which had the highest lead concentration (2,830 mg/kg) for vertical delineation. Sample analyses were limited to lead.

Additionally, Shaw personnel collected samples within the boundaries of the former Skeet Range. At shotgun ranges such as trap and skeet, shot is widely distributed. When a shotgun target is hit by a well-centered shot, only a relatively few of the several hundred pellets in the shot string actually strike the target. These may be deformed or deflected and fall to the ground nearby. Most of the pellets in the load continue beyond where the target was hit. According to guidance developed for small arms ranges, the positions of the shooters and the angles at which trap and skeet targets are thrown result in a fan-shaped shot fall zone. Depending on the load, the angle at which the shot was fired, and wind direction, typical lead skeet loads can reach about 680 feet from the shooter (NSSF, 1997). However, most skeet shot typically tends to fall roughly 375 to 600 feet from the shooter (NSSF, 1997). At the Picatinny Skeet Range, this shot fall zone is heavily vegetated with wetland and upland woody species. The shot fall zone is also very wet and marshy.

Fourteen surface soil samples (B1181SS-1 to B1181SS-14) were collected along transect lines through the shooting fan including the center line of the fan (**Figure 4**). Since this investigation was not intended to be a characterization of the former range, only a portion of the shot fall zone was sampled. An additional seven surface soil samples (B1181SS-15 to B1181SS-21) were collected along two transects from the range located outside the shooting fan. Samples were spaced approximately 150 to 100 feet apart along the transects depending on the proximity of other samples and any physical obstructions. Sample analyses were limited to lead.

Lead was detected in the 36 surface soil (SS) samples and the one subsurface soil sample. The lead concentrations ranged from 82.4 mg/kg to 209,000 mg/kg. The LOC for lead in soil is 800 mg/kg. Twenty-five (25) of the 37 samples exceeded the soil LOC.

The subsurface soil sample 180SS-15E/C, collected from 2.0 to 2.5 feet bgs, had a lead level of 6,930 mg/kg. The lead concentration exceeds the lead level detected in the surface soil sample (180SS-15E) collected at this location in 2006. The increased lead concentration in the subsurface soil sample may be the result of the fill used in the area or the leaching of the lead in the surface soil.

Twenty-one (21) of the 37 soil samples had percent solids levels below 50%. Many of these samples could be considered sediment samples based on the percent solids levels and their location within a wetland. Due to the magnitude of the lead concentrations detected in the samples, most samples exceed both the sediment LOC of 38.8 mg/kg and the soil LOC. Lead concentrations in the previous samples collected in 2005 and 2006 have been compared to the sediment LOC despite most samples exceeding 50% solids, because they are located within the wetlands portion of the sampled area. Sample 1181SS-1 with a percent solids content of 37 was not deemed a sediment sample because it is located on a maintained grass cover at the front of the former Skeet Range.

Three surface water and sediment samples (Samples 1181SW/SD-1 to 1181SW/SD-3) were collected from the drainage ditch located to the north of the range within the shot fall zone. These samples were also analyzed for lead.

The sediment (SD) concentrations ranged from 104 mg/kg to 21,500 mg/kg. All three concentrations exceed the sediment LOC of 38.8 mg/kg. Lead concentrations in the surface water (SW) samples ranged from 35.8 µg/L to 354 µg/L. All these concentrations exceed the surface water LOC of 3.2 µg/L. The highest surface water and sediment concentrations were located in the area of the highest soil concentrations. The surface water concentrations decreased downstream toward the confluence of the drainage ditch with Green Pond Brook (Shaw, 2008).

#### 2.1.3.3 June 2010 Investigation

Shaw performed an additional investigation at the former Skeet Range area in June 2010 which consisted of the installation of two monitoring wells (B1181MW-1 and B1181MW-2), sampling the newly installed and three existing monitoring wells (C-1A, C-1B, and DM19-3), soil sampling, and sediment sampling. The new monitoring wells were installed to determine the groundwater flow direction and to assess potential impacts to shallow groundwater proximal to and within the former Skeet Range. Evaluation of the groundwater elevations measured in the monitoring wells indicated the general groundwater flow direction is northwest toward Green Pond Brook (**Figure 8**).

***Groundwater Sampling Results***

A total of six groundwater samples were collected from the three existing monitoring wells and the two new wells. A duplicate groundwater sample was collected from monitoring well B1181MW-2. Arsenic was detected in two of the six groundwater samples at concentrations of 7.55 µg/L (C-1B) and 13.2 µg/L (DM19-3), both of which exceeded the arsenic LOC of 3.0 µg/L. Aluminum was detected in all six groundwater samples at concentrations ranging from 298 µg/L to 1,110 µg/L, all of which exceeded the aluminum LOC of 200 µg/L. Iron was detected in all six groundwater samples at concentrations ranging from 1,380 µg/L to 18,300 µg/L, all of which exceeded the iron LOC of 300 µg/L. Manganese was detected in all six groundwater samples at concentrations ranging from 1,400 µg/L to 3,350 µg/L, all of which exceeded the manganese LOC of 50 µg/L. Vanadium was detected in four of the six groundwater samples at concentrations ranging from 6.93 µg/L to 18.2 µg/L, all of which exceeded the vanadium LOC of 2.0 µg/L.

Arsenic is a known groundwater contaminant in the area and is likely from historic landfilling operations or contamination from other sites. Vanadium may also be related to historic landfilling operations in the area. While it is possible that the arsenic detections in groundwater could be related to skeet range ammunition, it is unlikely the arsenic and vanadium detections in groundwater are related to the historic operation of the former Skeet Range (Shaw, 2005; Shaw, 2009; Shaw, 2010c; Shaw, 2010d). Aluminum, iron, and manganese concentrations in groundwater are consistent with levels detected in wells throughout the base and are due to local geologic conditions. Despite the high concentrations of lead in the soil and given the shallow groundwater level, lead was not detected above the LOC in the groundwater, suggesting that the lead is absorbed to the soil and organic carbon, and it is not leaching into the groundwater or moving in solution. PAHs were not detected in the groundwater samples collected.

***Soil/Sediment Sampling Results***

A total of 16 surface soil/sediment samples were collected within the boundaries of the former Skeet Range and the associated impact fan in June 2010. Twelve of these samples (B1181SS-22 through B1181SS-33) were collected along the central and western transect lines within the boundaries of the shooting range fan. Sample B1181SS-35 was collected near the trap house where remnants of clay targets have accumulated. Samples B1181SS-36 and B1181SS-37 and sample B1181SS-38 were collected in the central and eastern portion of the shooting fan within the maximum shot fall zone to delineate the downgradient extent of the lead contamination. It should be noted that these "soil/sediment" samples were analyzed for percent solids in order to evaluate the samples as a soil or sediment when comparing to applicable LOCs. A discussion of these results is found below. Refer to the "*Picatinny Arsenal Former Skeet Range Investigation Data Report"* from 2010 for additional clarification as to what samples were considered sediment and what samples were considered soil (Shaw, 2010b).

Five PAHs were detected in one or more surface soil/sediment samples at concentrations greater than their respective LOCs. Benzo(a)anthracene (LOC = 2.0 mg/kg) was detected above the LOC in three samples at concentrations ranging from 3.61 mg/kg to 27.6 mg/kg. Benzo(a)pyrene (LOC = 0.2

mg/kg) was detected in 13 of 14 samples above the LOC at concentrations ranging from 0.301 mg/kg to 21.6 mg/kg. Benzo(b)fluoranthene (LOC = 2.0 mg/kg) was detected above the LOC in four samples at concentrations ranging from 3.79 mg/kg to 27.1 mg/kg. Dibenz(a,h)anthracene (LOC = 0.2 mg/kg) was detected in 8 of 14 samples above the LOC at concentrations ranging from 0.289 mg/kg to 4.88 mg/kg. Indeno(1,2,3-cd)pyrene (LOC = 2.0 mg/kg) was detected above the LOC in three samples at concentrations ranging from 2.66 mg/kg to 16.5 mg/kg.

Lead was detected in six surface soil samples at concentrations exceeding the lead soil LOC of 800 mg/kg. Lead concentrations exceeding the LOC ranged from 923 mg/kg to 84,700 mg/kg.

In addition to the surface soil/sediment samples, two sediment samples were also collected during this investigation from drainage channels within and adjacent to the northeastern Skeet Range impact fan. Five PAHs, benzo(b)fluoroanthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, fluoroanthene, and pyrene, were found at concentrations exceeding their respective sediment LOCs. Benzo(b)fluoroanthene (LOC = 0.0272 mg/kg) was detected above the LOC in sample B1181SD-4 DUP at a concentration of 0.227 mg/kg. Benzo(g,h,i)perylene (LOC = 0.17 mg/kg) was detected above the LOC in sample B1181SD-5 at a concentration of 1.69 mg/kg. Benzo(k)fluoroanthene (LOC = 0.0272 mg/kg) was detected above the LOC in sample B1181SD-4 DUP at a concentration of 0.287 mg/kg. Fluoranthene (LOC = 0.06423 mg/kg) was detected above the LOC in sample B1181SD-4 DUP at a concentration of 0.113 mg/kg. Pyrene (LOC = 0.053 mg/kg) was detected above the LOC in two samples at concentrations of 0.155 mg/kg and 0.467 mg/kg. Lead was also detected above the LOC (38.8 mg/kg) in sediment sample B1181SD-5 at a concentration of 387 mg/kg.

The highest lead concentrations in the soil/sediment samples collected during the 2010 investigation were primarily found within the maximum shot fall zone. However, concentrations of lead above the LOC were still detected in soil samples outside of the maximum shot fall zone and in sediment samples collected near the maximum extent of the northeastern shot fall zone.

Refer to **Figure 2** for the pattern/distribution of elevated lead concentrations in the area of the former Skeet Range. Refer to **Figures 3 and 4** for PAH and lead soil and sediment sample locations and concentrations.

Based on the results of the 2010 investigation, a RI was recommended to further delineate lead concentrations in the soil and sediment both horizontally and vertically, including outside the shot fall zone. The RI was proposed to also delineate the extent of PAH contamination in the soil and sediment. In addition, the RI was proposed to include a risk assessment to quantify risks associated with the contamination identified at the site and to evaluate whether remedial action will be needed due to historic operations of the former Skeet Range.

## 3.0 DATA QUALITY OBJECTIVES

The DQO process is the USEPA's recommended systematic planning tool when data are to be used to support site investigation, risk and remediation decisions.

The former skeet range site is located in an undeveloped portion of Picatinny Arsenal. There are no occupied buildings or paved roads. Based on the results of historical investigations, soil contaminants include lead and PAHs; surface water and sediment contaminants include lead. Groundwater flow is to the northwest toward Green Pond Brook. Possible sources of the contamination include former skeet range activities. Potential exposure pathways are discussed in **Section 5.0**. Since contamination exists, potential risks and hazards exist, but the actual impacts to receptors are not currently defined.

The following problem statements identify data gaps and areas of investigation that need to be addressed as part of the former skeet range RI:

1. The impact of the former skeet range activities on groundwater is not known. Possible groundwater contaminants associated with the former range that require characterization include metals and PAHs.
2. The nature and extent of surface soil contaminants (e.g., metals and PAHs) is not adequately defined. Characterization of surface soil is required to assess risk and develop remedial alternatives.
3. The nature and extent of subsurface soil contaminants (e.g., metals and PAHs) is not currently delineated. Characterization of surface soil is required to assess risk and develop remedial alternatives.
4. The nature and extent of surface water and sediment contaminants (e.g., metals and PAHs) is not adequately defined within the marsh and associated drainage channels. Characterization of surface water and sediment is required to assess risk and develop remedial alternatives.
5. Identify contaminant exposure pathways and determine site characteristics and contaminant concentrations required for protection of human health and the environment.

Decisions to be made concerning the former skeet range site defining the nature and extent of contaminants in site media, identifying impacted surface water bodies, identifying exposure pathways from media to receptors, and decisions concerning the potential for risks to human health and the environment.

Information required to address the goals of the study will include analytical data to determine site impacts, analytical data to delineate the contamination boundaries, analytical data to identify the location of maximum concentrations and determination of hydraulic gradients to identify transport pathways and estimate flow rates. This investigation will generate new data from soil, groundwater, surface water and sediment samples collected during the investigation. Groundwater will be collected from fixed monitoring well locations; soil, surface water and sediment samples will be collected manually. Based on the information collected to date, lead and PAHs are the primary concerns.

Sampling locations will be based on site historical data and accessibility to the proposed locations. Sampling crews may be unable to access some locations because of dense vegetation, marshy conditions or ponded water. Samples will be collected for chemical analysis to characterize the nature and extent of impacted media. Samples will be analyzed for munition metals (i.e., lead, antimony, arsenic, copper, zinc, and iron) and PAHs. Samples will be collected following the procedures described in **Section 4.0**.

The location of the former skeet range is shown on **Figure 1**. The work plan uses the current site boundaries and the skeet range impact fan to guide the limit of sampling activities; however, sampling outside of the current boundary is also proposed. The arbitrary nature of this site boundary should be noted. Additional investigations of contaminant extent will be pursued regardless of the site boundary. Due to the potential for migration of contamination by overland flow to local surface water bodies, surface water and sediment samples will be collected within the marsh and its associated drainage channels.

However, no surface water and sediment samples will be collected from Green Pond Brook. The EPA-approved remedial action for this portion of GPB (Region 4) includes annual chemical and biological monitoring to determine whether the health of ecological receptors within Region 4 is being affected by the Region 4 Area of Concern. Thus, no additional characterization of GPB will be performed as part of the skeet range RI.

The analytical results from the RI samples will be evaluated along with data from previous investigations to more fully characterize the extent of soil, surface water, sediment and groundwater contamination at the site. Data will be compared to all appropriate screening criteria including, but not limited to, the following:

- New Jersey soil remediation standards.
- Groundwater standards, including maximum contaminant levels (MCLs), and New Jersey Groundwater Quality Standards.
- Appropriate ecological screening values.
- Background soil, sediment and surface water levels

Samples collected during implementation of the sampling effort will be analyzed using certified USEPA SW-846 Update III methods as presented in **Section 4.0**. Reporting limits for the various analytical parameters will be appropriate for comparing data against the screening criteria. Data will be reported and validated in accordance with the stipulated requirements for the generation of definitive data.

# 4.0 REMEDIAL INVESTIGATION SAMPLING PROCEDURES

The former Skeet Range RI will involve additional investigation of groundwater, soil, sediment, and surface water within and adjacent to the former Skeet Range impact fan, primarily for purposes of delineation of elevated lead and PAH levels. The proposed sampling is also expected to characterize the nature and extent of contamination related to past activities at the former Skeet Range. The investigation is broken down into a number of sequential steps which are summarized as follows:

- Measurement of water levels in five existing monitoring wells (C-1A, C-1B, DM19-3, B1181MW-1, and B1181MW-2);
- Sampling of these five existing monitoring wells located within and around the former Skeet Range;
- Collection of 25 surface soil samples within and around the former Skeet Range impact fan at new locations (B1181SS-34, and B1181SS-39 through B1181SS-62);
- Collection of five subsurface soil samples within the former Skeet Range impact fan at former sampling locations (B1181SS-10D, B1181SS-14C, B1181SS-23C, B1181SS-25C, and B1181SS-35C);
- Collection of three sediment and surface water samples from drainage channels located adjacent to the eastern and northeastern former Skeet Range impact fan (B1181SD/SW-6, B1181SD/SW-7, and B1181SD/SW-8) at new locations;
- Collection of two sediment samples from drainage channels located within the former Skeet Range impact fan (B1181SD-11 and B1181SD-12);
- Collection of one subsurface sediment sample within the former Skeet Range impact fan at a former sampling location (B1181SD-3C);
- Collection of two sediment and surface water samples from random areas within or adjacent to the former Skeet Range impact fan dependent upon field observations and conditions;
- Collection of Global Positioning System (GPS) coordinates for each sample location using a hand-held device;
- Performance of human health and ecological risk assessments;
- Evaluation of the resultant analytical data and risk assessment results; and
- Preparation of a RI Report (RIR).

Prior to site investigation activities, PTA's Safety Office will be consulted regarding the need for unexploded ordnance (UXO) avoidance support. If necessary, a Shaw or qualified UXO subcontractor will prepare a UXO Avoidance Work Plan for the site.

Sample analyses will include PAHs and metals. The inorganic analysis will include the following six metals, which are constituents used in the production/manufacturing of small arms range ammunition: lead, antimony, arsenic, copper, zinc, and iron. Lead is the primary component of a bullet and accounts for more than 85% of the weight of the bullet (ITRC, 2003; ITRC, 2005). These six metals will be collectively referred to as the Munitions Metals. Some of the soil and sediment samples will be analyzed for lead only. Justification for analysis of these six metals can be found in the Interstate Technology Regulatory Council's "*Environmental Management at Operating Outdoor Small Arms Firing Ranges*" publication from 2005. All investigations and analyses will be performed in accordance with regulatory approved Picatinny field sampling procedures (ICF KE, 1998) and Picatinny quality assurance project plan (IT, 1999).

Select investigation tasks are addressed further in the following sections.

## 4.1 GROUNDWATER SAMPLING

Prior to groundwater sampling, synoptic water level measurements will be conducted at monitoring wells C-1A, C-1B, DM19-3, B1181MW-1, and B1181MW-2. One round of groundwater

samples will be collected from these wells. The wells will be purged and sampled by the USEPA Region 2 low-flow methodology using decontaminated Grundfos submersible pumps (USEPA, 1998). Decontamination of the submersible pumps will be conducted in accordance with the approved Picatinny field sampling procedures (ICF KE, 1998) and NJDEP's Field Sampling Procedures Manual (NJDEP, 2005a). The proposed wells to be sampled are depicted on **Figure 5**. Groundwater quality parameters will be measured using a calibrated multimeter. Temperature, pH, conductivity, oxidation-reduction potential (ORP), dissolved oxygen (DO), and turbidity will be recorded during purging. All samples will be analyzed for Munitions Metals using USEPA Method 6010B and PAHs by USEPA Method 8270C. All sample analyses will be performed by a laboratory certified by the NJDEP for the selected methods.

Quality Assurance/Quality Control (QA/QC) samples will be collected as part of the groundwater sampling program. One field rinsate blank will be collected of a decontaminated Grundfos pump. One duplicate sample will be collected from one of the wells. All rinsate and duplicate samples will be analyzed for Munitions Metals and PAHs. **Table 1** presents the number of primary samples and QC samples to be collected. **Table 2** provides the requirements for sample containers, preservatives, and holding times for the proposed analyses. **Table 3** lists each proposed RI sample location's medium, analytes, and rationale. **Table 4** summarizes each former Skeet Range historical sampling event's details including the number of samples from each medium and the analyses. **Table 5** summarizes the groundwater reporting limits and standards for the RI sampling event.

## 4.2 SOIL SAMPLING

A total of 30 soil samples will be collected within and around the boundaries of the former Skeet Range and the associated impact fan in order to characterize the nature and extent of contamination in soil at the site. Twenty-five of these samples will be collected from the surface for purposes of horizontal delineation. Three of these horizontal delineation soil samples (B1181SS-34, B1181SS-43, and B1181SS-44) will be collected along and within the northern boundary of the former Skeet Range impact fan. It should be noted that B1181SS-34 was proposed to be collected during the sampling event in June 2010; however, accumulated water and excessive vegetation in the area prevented sample collection at that time. Four horizontal delineation soil samples (B1181SS-39 through B1181SS-42) will be collected within and adjacent to the northwestern former Skeet Range maximum shot fall zone. Five horizontal delineation soil samples (B1181SS-45 through B1181SS-49) will be collected along a fire road to the east of the former Skeet Range impact fan. Seven horizontal delineation soil samples (B1181SS-50 through B1181SS-53 and B1181SS-59 through B1181SS-61) will be collected between Shinkle Road and the northern portions of the former Skeet Range impact fan. Five horizontal delineation soil samples (B1181SS-54 through B1181SS-58) will be collected to the west or northwest of the former Skeet Range impact fan. One horizontal delineation soil sample, B1181SS-62, will be collected within the former Skeet Range maximum shot fall zone.

The remaining five soil samples (B1181SS-10D, B1181SS-14C, B1181SS-23C, B1181SS-25C, and B1181SS-35C) will be collected at former soil sampling locations for purposes of vertical delineation. Soil sample B1181SS-10D will be collected from 4.0-4.5 feet bgs. Soil samples B1181SS-14C, B1181SS-23C, B1181SS-25C, and B1181SS-35C will be collected from 2.0-2.5 feet bgs. Proposed soil sampling locations are depicted on **Figure 5**.

Subsurface soil samples to be collected in this investigation are denoted by suffixes B, C, and D. Typically, "B" refers to the 1.0-1.5 feet interval, "C" refers to the 2.0-2.5 feet interval, and "D" refers to the 4.0-4.5 feet interval.

Subsurface sampling location B1181SS-23C was selected because it is the location of the highest PAH concentrations during the 2010 investigation. Subsurface sampling location B1181SS-35C was selected because it was the most obvious location to be impacted by PAHs related to former Skeet Range activities based on the large amount of clay target fragments observed at this location. If complete vertical delineation is not achieved during the RI, additional vertical delineation may be performed during the feasibility study or remedial action. All soil samples will be collected using decontaminated stainless-steel bucket augers or stainless-steel trowels. Decontamination of the augers and trowels will be conducted in accordance with the approved Picatinny field sampling procedures (ICF KE, 1998) and NJDEP's Field Sampling Procedures Manual (NJDEP, 2005a). A sufficient amount of soil from the specified soil interval will be placed on a decontaminated stainless-steel tray for mixing. After any rocks

or organic matter have been removed, the soil will be homogenized using the coring and quartering method. Once the soil has been homogenized, the required soil volumes will be placed in the sample bottles.

Sixteen of the soil samples (B1181SS-34, B1181SS-39 through B1181SS-43, B1181SS-45, B1181SS-46, and B1181SS-54 through B1181SS-61) will be analyzed for the six Munitions Metals by USEPA Method 6010B and PAHs by USEPA Method 8270C. Two of the soil samples (B1181SS-23C and B1181SS-35C) will be analyzed for PAHs. One of the soil samples, B1181SS-44, will be analyzed for the six Munitions Metals. The remaining 11 soil samples will be analyzed for lead.

The soil samples will be collected in accordance with the approved Standard Operating Procedure for soil sampling as presented in the *Picatinny Arsenal Facility-Wide Field Sampling Plan* (ICF KE, 1998). All samples will be collected in accordance with the *Technical Requirements for Site Remediation* (NJDEP, 2005b) including collection of samples in discrete six-inch intervals. All analyses will be conducted by a laboratory certified by the NJDEP to perform the necessary analytes.

QA/QC samples will be collected as part of the soil sampling program. Two field rinsate blanks will be collected from decontaminated soil sampling equipment. Two duplicate samples will be collected from the soil sample locations. All rinsate and duplicate samples will be analyzed for the Munitions Metals and PAHs. **Table 1** presents the number of primary samples and QC samples to be collected. **Table 2** provides the requirements for sample containers, preservatives, and holding times for the proposed analyses. **Table 3** lists each proposed RI sample location's medium, analytes, and rationale. **Table 4** summarizes each former Skeet Range historical sampling event's details including the number of samples from each medium and the analyses. **Table 6** summarizes the soil reporting limits and standards for the RI sampling event.

## 4.3 SURFACE WATER AND SEDIMENT SAMPLING

Eight sediment and five surface water samples will be collected within and around the boundaries of the former Skeet Range impact fan. These samples will be collected for purposes of additional characterization of sediment and surface water within and adjacent to the former Skeet Range. Sediment and surface water samples B1181SD/SW-6 through B1181SD/SW-8 will be collocated and collected to the east and northeast of the former Skeet Range impact fan. Sediment and surface water samples B1181SD/SW-9 and B1181SD/SW-10 will be collocated and collected at random locations either within or adjacent to the former Skeet Range impact fan depending on field conditions encountered and site observations during sampling. Sediment sample B1181SD-3C will be collected from a depth of 2.0-2.5 feet bgs for purposes of vertical delineation in an area of known sediment impacts. Sediment samples B1181SD-11 and B1181SD-12 will be collected for purposes of delineation in a drainage channel located within the former Skeet Range impact fan. All of the sediment samples, with the exception of B1181SD-3C and B1181SD-7C, will be collected from the surface (0-0.5 feet bgs). The sampling will be performed during months of minimal vegetation growth (October through March) to allow for collection of the maximum amount of samples. Proposed sediment and surface water sample locations are depicted on **Figure 5**.

Subsurface sediment samples to be collected in this investigation are denoted by suffixes B, C, and D. Typically, "B" refers to the 1.0-1.5 feet interval, "C" refers to the 2.0-2.5 feet interval, and "D" refers to the 4.0-4.5 feet interval.

The sediment samples will be collected using a stainless-steel trowel. A sufficient amount of sediment will be placed on a decontaminated stainless-steel tray for mixing. Decontamination of the trowels and trays will be conducted in accordance with the approved Picatinny field sampling procedures (ICF KE, 1998) and NJDEP's Field Sampling Procedures Manual (NJDEP, 2005a). After any rocks or organic matter have been removed, the sediment will be homogenized using the coring and quartering method. Once the sediment has been homogenized, the required sediment volumes will be placed in the sample bottles.

The surface water samples will be collected using a decontaminated stainless-steel pitcher and will be transferred directly to pre-preserved sample bottles for shipping to the laboratory. Surface water parameters will be measured using a calibrated multimeter, and temperature, pH, conductivity, ORP, DO, and turbidity will be recorded prior to sampling.

Six of the sediment samples (B1181SD-3 and B1181SD-6 through B1181SD-10) will be analyzed for the six Munitions Metals by USEPA Method 6010B and PAHs by USEPA Method 8270C. The remaining two sediment samples (B1181SD-11 and B1181SD-12) will be analyzed for lead by USEPA Method 6010B. All of the surface water samples will be analyzed for the six Munitions Metals by USEPA Method 6010B and PAHs by USEPA Method 8270C.

The sediment samples will be collected in accordance with the approved Standard Operating Procedure for sediment sampling as presented in the *Picatinny Arsenal Facility-Wide Field Sampling Plan* (ICF KE, 1998). All samples will be collected in accordance with the *Technical Requirements for Site Remediation* (NJDEP, 2005b) including collection of samples in discrete six-inch intervals. All analyses will be conducted by a laboratory certified by the NJDEP to perform the necessary analytes.

QA/QC samples will be collected as part of the sampling program. One field rinsate blank will be collected from decontaminated sediment sampling equipment and one field rinsate blank will be collected from decontaminated surface water sampling equipment (i.e., stainless steel pitcher). One duplicate sample will be collected from the sediment sample locations and one duplicate sample will be collected from the surface water sampling locations. All rinsate and duplicate samples will be analyzed for the Munitions Metals and PAHs. **Table 1** presents the number of primary samples and QC samples to be collected. **Table 2** provides the requirements for sample containers, preservatives, and holding times for the proposed analyses. **Table 3** lists each proposed RI sample location's medium, analytes, and rationale. **Table 4** summarizes each former Skeet Range historical sampling event's details including the number of samples from each medium and the analyses. **Tables 7 and 8** summarize the surface water and sediment reporting limits and standards, respectively for the RI sampling event.

# 5.0 RISK ASSESSMENT METHODOLOGY

## 5.1 HUMAN HEALTH RISK ASSESSMENT

### 5.1.1 Screening Level Human Health Risk Assessment

In order to determine the potential for risks to human health from exposure to constituents detected in sampled media at the former Skeet Range, a human health risk assessment (HHRA) will be conducted. The first step of the RA process will be to screen all chemicals detected against health-based criteria. If all chemicals are eliminated from evaluation using this screening procedure (i.e., if all chemical concentrations are lower than respective screening levels), the former Skeet Range will be eliminated from further evaluation. While the former Skeet Range is not expected to pass this screening level assessment, completion of this step is expected to focus the HHRA on chemicals of potential concern (COPC), such as lead. Thus, chemicals retained for evaluation following this screening procedure, will be further evaluated in the RA processes. The second step involves the development of a baseline RA (**Section 5.1.2**).

The HHRA will be conducted following procedures outlined in USEPA's *Interim Final Risk Assessment Guidance for Superfund (RAGS)—Human Health Evaluation Manual (Part A)* (USEPA, 1989). Other resources that will be used when performing the RA include: "*Superfund's Standard Default Exposure Factors*" (USEPA, 1993); *Role of Baseline RA in Superfund Remedy Selection Decision* (USEPA, 1991a); *Calculating Upper Confidence Limits for Exposure Point Concentrations (EPCs) at Hazardous Waste Sites* (USEPA, 2002a); *Human Health Toxicity Values in Superfund RAs* (USEPA, 2003); Regional Screening Levels (RSLs) (USEPA, 2010a), RAGS Part D and Part E guidance (USEPA, 2001 and 2004) and RAGS Part F guidance (USEPA, 2009). As is the case with a baseline HHRA, the Screening Level HHRA will consist of four major components:

- Data Collection and Evaluation
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization

Data collection and evaluation will consist of collecting additional analytical data for the various environmental media at the former Skeet Range in order to fill existing data gaps. COPCs will also be identified in this step.

A screening of detected constituents to select COPCs will be conducted for media sampled at the former Skeet Range. The screening values to be used will be the USEPA RSLs conservatively based on residential land use (USEPA, 2010a); in case the Facility is converted to residential land use in the future.

Background concentrations will not be considered in the COPC identification step. Comparisons to background concentrations of constituents (from available base-wide background studies or from other published regional studies) will be conducted during the risk characterization step as an additional line of evidence to assess the environmental quality of sampled media at the former Skeet Range.

The COPC screening process will be documented in RAGS Part D, Table 2 format.

Exposure assessment will consist of the development of a conceptual site model (CSM) (**Figure 6** presents an example) that will identify the potentially exposed human populations and the potential exposure pathways by which human receptors could potentially be exposed to contaminants identified at the former Skeet Range. Receptors to be included are current and future on-site workers and construction workers, and hypothetical future on-site adult and child residents.

The toxicity assessment for the screening level HHRA will consist of identifying and determining the appropriate screening levels from the RSLs (USEPA, 2010a).

The results of the screening level HHRA will be a determination of whether human health risks and/or hazards are potentially present and may warrant more in-depth investigation (i.e., baseline HHRA), or that human health risks are negligible and no further HHRA is necessary at the former Skeet Range.

### 5.1.2 Baseline Human Health Risk Assessment

As described in **Section 5.1.1**, a baseline RA will be conducted if COPCs are retained as part of the screening level HHRA. Appropriate RAGS D data summary tables will present the frequencies of detection, the ranges of concentrations, and the range of nondetect concentrations for chemicals selected as COPCs at the former Skeet Range.

The potential pathways by which individuals may be exposed to the COPCs in each environmental medium will be identified and exposures will be quantified. Potential current and future exposure pathways through which populations could be exposed to chemicals at or originating from the former Skeet Range will be discussed. For each pathway selected for quantitative evaluation, the chemical concentrations at the points of exposure will be determined, and the methodology for calculating potential chemical intakes for each pathway selected for quantitative evaluation will follow standard RA guidance.

***Potential Human Exposure Pathways***

An exposure pathway describes the course a chemical takes from the source to the exposed individual, and is defined by four elements: 1) a source and mechanism of chemical release to the environment; 2) an environmental transport medium (e.g., groundwater) for the released chemical; 3) a point of potential contact with the contaminated medium (referred to as the exposure point); and 4) an exposure route (e.g., ingestion) at the contact point. An exposure pathway is considered complete when all four elements are present. In RAs, only complete exposure pathways are quantitatively evaluated. Exposure pathways are depicted in a human health CSM for the former Skeet Range (**Figure 6**).

The CSM integrates the physical characteristics of the former Skeet Range, potentially exposed populations, sources of contamination, and contaminant fate and transport processes in order to identify potential exposure routes for likely receptor populations.

When conducting an exposure assessment, USEPA (1989, 1991b, and 1997a) guidance requires that plausible exposures under both current and future land-use scenarios be evaluated. Accordingly, potential human exposure pathways are identified for current and potential future land-use conditions at the former Skeet Range. The current land-use scenario assumes conditions as they currently exist, while the future land-use scenario evaluates potential risks that may be associated with probable changes in former Skeet Range land use, assuming no remedial action occurs. The potential exposure pathways through which humans could be exposed to contamination at the former Skeet Range are discussed below.

The general land use at the former Skeet Range is commercial/industrial. Currently, no Picatinny Arsenal workers are employed at the site. The marshy condition of the site limits the potential land use. However, future land use may include residential development, if Picatinny undergoes Base Realignment and Closure (BRAC), thus future residential adults and children will be evaluated as potential receptors to former Skeet Range media.

The site-specific baseline RA will include a detailed, site -specific exposure assessment to determine which receptors and pathways are to be evaluated. Since the evaluated former Skeet Range will likely remain in its current commercial/industrial status, the most likely receptors at the former Skeet Range are routine workers, who work at the adjacent sites such as the Burning Ground on a regular basis. As a result, routine workers will be evaluated in the baseline RA. Other receptors may include construction workers that may perform intrusive work to repair underground utilities or construct future buildings. Although other receptors, such as caretakers, maintenance workers, trespassers, or on-site adult visitors, may be present at the former Skeet Range, they will not be quantified in the baseline RA as compelling information does not exist to suggest these receptors would be more exposed to Skeet Range constituents, e.g., the COPC dose would not be greater than for the routine worker or the construction worker. Since the site may become BRAC in the future, and the evaluated areas could become residential, future child and adult residents will be evaluated as potential receptors in the baseline RA.

Potential exposure pathways associated with groundwater at the former Skeet Range will be considered for evaluation in the baseline RA. Currently, impacted groundwater beneath the former Skeet Range is not used as a drinking water source, and drinking water used at Picatinny is obtained from

treated on-base supply wells. As a result, there are no complete direct exposure pathways for groundwater under current land-use conditions. Although groundwater is not expected to be used at the former Skeet Range, future exposure scenarios (including ingestion, dermal contact, and inhalation) for potential residential and routine worker exposures will be quantified. It should be noted that the closest water supply well to the former Skeet Range is located approximately 7,000 feet upgradient of the Skeet Range); any water supply wells located downgradient of the Site will be carefully evaluated in the HHRA.

Groundwater inhalation exposure for a construction worker in a trench could occur under the current/future timeframe, and this exposure pathway could be quantified using the Virginia Department of Environmental Quality (VDEQ) (2008) Trench Model (as NJDEP does not currently recommend a Trench Model of their own). However, as volatile organic compounds (VOCs) are not expected in groundwater, they are not included for chemical analysis. Therefore, this pathway is incomplete. The depth to groundwater is not greater than 10 feet bgs, as it is typically found from approximately 0 to 2 feet bgs (much of the Site is a wetland). As shown on the CSM (Figure 6), incidental ingestion and dermal contact with groundwater is shown as "insignificant" because construction workers are not expected to incidentally ingest groundwater that would pool at their feet in an excavation trench, and they are assumed to be wearing heavy work boot. In addition, if significant construction work were to occur at the Site (such as the installation of underground utilities), it is likely that induced groundwater drawdown would occur to facilitate such construction, resulting in minimal groundwater in such a trench. Based on this discussion, these groundwater exposure pathways were evaluated for the construction worker and deemed to be toxicologically insignificant.

Potential exposure pathways associated with surface soil at the former Skeet Range will also be considered under both current and future land-use conditions. The major exposure pathways by which routine workers could be exposed to surface soil contamination are via incidental ingestion and dermal absorption. Accordingly, these pathways will be evaluated for routine workers in the baseline RA. Exposures due to inhalation of airborne contaminants released from soil will also be evaluated.

If lead is selected as COPC in soil, this inorganic will be evaluated using the Integrated Uptake Biokinetic (IEUBK) Model and the Adult Lead Model (ALM), respectively, for children and pregnant industrial workers.

Ground-intrusive or excavation activities may infrequently take place at the former Skeet Range under current land-use conditions and may occur more frequently in the future if development occurs. Therefore, potential construction/excavation worker exposures to chemicals in total soil (surface plus subsurface soil) could occur via incidental ingestion, dermal absorption, and inhalation and these pathways will be quantified in the baseline RA. As mentioned previously, construction worker exposure to groundwater may occur, and the inhalation exposure pathway will be quantified for COPCs in groundwater.

In summary, the following pathways will be quantitatively evaluated in the baseline RA:

- Incidental ingestion, dermal absorption and inhalation of chemicals in surface soil (0-1 feet) by current and future routine workers;
- Incidental ingestion, dermal absorption and inhalation of chemicals in total soil (surface plus subsurface soil, 0-10 feet) by future adult and child residents;
- Incidental ingestion, dermal absorption, and inhalation of chemicals in total soil (surface plus subsurface soil, 0-10 feet) by current and future construction workers;
- Inhalation of chemicals in groundwater by on-site current and future construction workers in a trench;
- Ingestion, dermal absorption, and inhalation of chemicals in groundwater by potential on-site future adult and child receptors and potential future routine workers; and
- Ingestion and dermal absorption of chemicals in surface water and sediment by current and future routine workers, and future adult and child residents.

In accordance with USEPA guidance, reasonable maximum exposures (RME) will be calculated to provide upper-bound estimates of exposure. In calculating intakes, exposure factors representing RME are needed. The RME is defined as the highest exposure that is reasonably expected to occur (using exposure factors above the 90$^{th}$ percentile). The majority of the exposure factors will be USEPA defaults (USEPA, 1991b, 1993, 2004).

To evaluate the magnitude of exposures and risks that may be experienced by an individual, the concentration of the COPCs in the exposure medium must be known or estimated. This concentration is referred to as an EPC. The most appropriate measurement of EPC for exposure to environmental chemical concentrations is the arithmetic mean. To account for uncertainty associated with this value, USEPA guidance requires the use of the 95% upper confidence limit (UCL) on the arithmetic mean concentration for the estimation of the RME risk (USEPA, 2002a). The term RME is defined as the maximum exposure that is reasonably expected to occur at a site (USEPA, 1989). The 95% UCL is typically used as an appropriate estimate of concentrations likely to be contacted over time, and is the recommended RME EPC in HHRAs. Calculation of the UCL is dependent on the underlying distribution of sample data. Output from USEPA's ProUCL software (USEPA, 2010b) documenting the EPC statistics will be included in the baseline HHRA.

Complete pathways involving intermedia transfers between soil or groundwater and air will be quantified for the baseline HHRA, as volatile groundwater COPCs are expected to be identified during the screening process. The determination of air concentrations will require the use of modeling. These pathways include:

- Release of volatiles and particulates from soil to the ambient air.
- Release of volatiles from groundwater to trench air (during construction activities).
- Release of volatiles from groundwater to indoor air during future household or office use of groundwater.
- Release of volatiles from soil or groundwater to indoor air via vapor intrusion (VI).

To evaluate the potential risk from wind-blown dust, a soil-to-air particulate emission factor (PEF) will be calculated based on the methods described in USEPA guidance (USEPA 1996, 2002b). The PEF converts concentrations of constituents in soil to concentrations on dust particles in the air (PM10) as a result of fugitive dust emissions from bare surfaces of fine-grained soils. Soil-to-air volatilization factors (VFs) will be calculated for each volatile COPC to define the relationship between the soil concentration and ambient air concentration. Chemical-specific VFs will be calculated using the models described in USEPA (1996) and USEPA (2002b).

## 5.2 ECOLOGICAL RISK ASSESSMENT

### 5.2.1 Screening Level Ecological Risk Assessment

The potential for ecological risks from exposures to contaminants detected at the former Skeet Range will be assessed through the completion of a screening level ecological risk assessment (SLERA). The SLERA will be conducted in accordance with the guidelines set forth in *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997b), *Guidelines for Ecological Risk Assessment* (USEPA, 1998), *Risk Assessment Handbook, Volume II: Environmental Evaluation* (USACE, 1996), and *Tri-Service Procedural Guidelines for Ecological Risk Assessment* (USAEC, 2000).

The SLERA will consist of the following components:

- Description of the environmental setting at the former Skeet Range, and development of a CSM (**Figure 7**).
- Discussion of the constituents detected at the former Skeet Range, primarily in soils, surface water and sediment. For groundwater, no ecological exposure to constituents of potential ecological concern (COPECs) is expected to occur.
- Discussion of COPECs fate and transport.

- Description of the ecotoxicity of the COPECs detected at the former Skeet Range.
- Discussion of the potential ecological receptors at the former Skeet Range.
- Description of the complete exposure pathways at the former Skeet Range.
- Discussion of the screening level assessment endpoints.
- Discussion of the ecological screening values for the various environmental media at the former Skeet Range.
- Description of the EPCs of the different COPECs in each of the environmental media at the former Skeet Range.
- Calculation of screening level hazard quotients for each COPEC detected in each environmental medium.
- Uncertainty analysis.
- SLERA summary and conclusions.

The SLERA will quantitatively evaluate the following ecological receptors: plants, terrestrial and aquatic invertebrates, American woodcock, Bobwhite quail, short-tailed shrew, vole, marsh wren, and raccoon. These wildlife receptors include three mammals and three birds, which have relatively small home ranges, and as such are expected to have a greater potential for impact than wildlife with much larger home ranges, include carnivores, omnivores, and herbivores, and three of the wildlife species are included as assessment receptors in USEPA's Soil Screening Level (SSL) Guidance, such as the Eco SSL for Lead (USEPA, 2005). The exposure pathways to be quantified will be incidental ingestion of soil and/or sediment, and ingestion of surface water and food items that are modeled to bioaccumulate COPECs in food, such as plants, terrestrial invertebrates, small mammals or birds, and/or benthic invertebrates. As the surface water at the Site consists of small drainage ditches that are stagnant and highly turbid (see **Photographs** at the end of this work plan), fish are not expected and therefore no piscivores will be included as wildlife receptors. The ditches are very shallow and turbid and are not expected to support fish populations of sufficient mass to serve as prey for piscivorous wildlife such as osprey, great blue heron, or mink. In addition, the PAHs being analyzed are not known to be especially important bioaccumulators, as PAHs have been shown to be metabolized by fish.

The raccoon and marsh wren are specifically included to serve as aquatic receptors potentially exposed to COPECs in sediment and sediment-related food items. The other four wildlife receptors (woodcock, quail, shrew, and vole) will be considered primarily as terrestrial species potentially exposed to soil. Hazard quotients estimated for the six wildlife receptors, if found to be elevated above 1, will be evaluated in more detail, examining such factors as hazard drivers and pathways of most concern, toxicity reference values, and the potential density of wildlife receptors expected at the site and whether or not viable breeding populations are likely to be present. For surface water, sediment, and soil direct contact toxicity exposure, measured COPEC concentrations will be compared with readily-available plant, soil invertebrate, benthic invertebrate and aquatic biota toxicity benchmarks, such as water quality criteria for the protection of aquatic life, sediment screening benchmarks, and plant and terrestrial invertebrate toxicity benchmarks. Additional lines of evidence, such as visual signs of vegetative stress and other site-specific information, will also be used in the direct contact assessment. If any benchmark exceedances are noted, the technical basis of the benchmarks will be investigated to determine whether or not they are appropriate for Picatinny.

The results of the SLERA will provide sufficient information for risk managers to make a decision of either negligible ecological risk at the former Skeet Range (no further ecological risk assessment (ERA) is necessary) or further ERA (baseline ERA) is warranted.

As Green Pond Brook has been assessed previously and the EPA-approved remedial action for this portion of Green Pond Brook (Region 4) includes annual chemical and biological monitoring, no additional characterization of Green Pond Brook is being performed as part of the Skeet Range RI.

### 5.2.2 Baseline Ecological Risk Assessment

A baseline ERA will only be recommended for the former Skeet Range where the following three conditions are met:

- Ample habitat exists wherein ecological receptors can occur (see additional discussion below).
- Contaminants are present in environmental media at levels that could pose risk.
- A complete exposure pathway exists whereby the ecological receptors could be exposed to the chemical contaminants.

If any one of these conditions is not met, then the potential for ecological receptors to be exposed to contaminants at levels that may pose a risk does not exist, and no further action (NFA) is necessary to address ecological concerns. Determining whether contaminants are present at levels that could pose risk will be accomplished through the SLERA. If these conditions are met, a baseline ERA may be recommended.

It should be noted that a BERA will only be considered, if SLERA results suggest unacceptable ecological hazards, and it is determined that habitat at the Range is of sufficient size and quality to support viable populations of ecological receptors important to stakeholders. The potential for viable populations will be assessed using information on wildlife density and the size of the site (including habitat considerations), in order to estimate whether or not a sufficient number of breeding pairs (e.g., five) are expected to be present. EPA guidance does not provide a requisite number of breeding pairs for a viable population, or specify which wildlife receptors should be considered sufficiently important to conclude that the potential for ecological risk exists at a site. Therefore, the decision on whether or not a BERA is needed will be a scientific management decision point (SMDP) made in consultation with EPA.

The objective of a baseline ERA would be to evaluate the potential for adverse effects to ecological receptors from former Skeet Range contaminants. The potential for adverse effects to ecological receptors is dependent on the ecological receptor species, the contaminants present, and the pathways by which ecological receptors could be exposed to the contaminants. Since the nature and extent of contamination is still being investigated, it would be premature to develop a plan to evaluate eco-receptors at this time. Following the SLERA, a work plan would be developed for a baseline ERA at the former Skeet Range if deemed necessary. The work plan would modify the CSM (**Figure 7**); identify the assessment endpoints, the hypotheses being tested and the measurement endpoints selected for evaluation for the baseline ERA.

# 6.0 REMEDIAL INVESTIGATION REPORTING

At the conclusion of field activities and the risk assessment, the sampling and risk assessment data will be summarized in a RIR. The analytical data will be evaluated in comparison with the applicable regulatory standards. The RIR will include summary tables for all groundwater, surface water, soil, and sediment sampling data. Well purge sheets and other sampling data will be included in RIR appendices. The RIR will include figures depicting sampling locations and chemical concentrations.

The data gathered during the RI activities will be used to evaluate and delineate groundwater, surface water, soil, and sediment impacts. Conclusions and recommendations will be presented depending on the results of the data collected and the risk assessment.

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# TABLES

# FIGURES

# PHOTOGRAPHS