National Aeronautics and Space Administration

Record of Decision

Operable Unit 8

Formerly Used Defense Site Project 9 – Skeet Range Munitions Response Site

Goddard Space Flight Center

Wallops Flight Facility

Wallops Island, Virginia

August 2024

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Acronyms and Abbreviations

ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CNAAS	Chincoteague Naval Auxiliary Air Station
COC	chemical of concern
COPC	chemical of potential concern
CSF	cancer slope factor
CSM	Conceptual Site Model
CY	cubic yards
DoD	Department of Defense
ECO SSL	Ecological Soil Screening Level
EPC	exposure point concentration
ERA	ecological risk assessment
ESD	Explanation of Significant Differences
FS	Feasibility Study
FUDS	Formerly Used Defense Site
GSFC	Goddard Space Flight Center
HHRA	baseline human health risk assessment
HI	hazard index
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic
ILCR	incremental lifetime cancer risk
IUR	inhalation unit risk
LOAEL	lowest observed adverse effect level
LTM	long-term monitoring
LUC	land use control
MC	munitions constituents
MEC	munitions and explosives of concern
mg/kg	milligram per kilogram
MOA	Memorandum of Agreement
MRS	Munitions Response Site
NA	not applicable
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAEL	no observed adverse effect level
NPW	net present worth
NTCRA	non-time-critical removal action

OU	Operable Unit
O&M	operation and maintenance
PAH	polycyclic aromatic hydrocarbon
PRG	preliminary remediation goal
RAO	remedial action objective
RBC	risk-based concentration
RCRA	Resource Conservation Recovery Act
RfC	reference concentration
RfD	reference dose
RI	Remedial Investigation
RSL	Regional Screening Level
ROD	Record of Decision
SI	Site Inspection
SLERA	screening level ecological risk assessment
TRV	toxicity reference value
USACE	United States Army Corps of Engineers
USC	United States Code
USEPA	United States Environmental Protection Agency
UXO	unexploded ordnance
VDEQ	Virginia Department of Environmental Quality
WFF	Wallops Flight Facility
µg/kg	microgram per kilogram

1.0 DECLARATION

1.1 SITE NAME AND LOCATION

Operable Unit (OU) 8
Formerly Used Defense Site (FUDS)
Project 9 – Skeet Range Munitions Response Site
NASA Wallops Flight Facility
Wallops Island, Virginia
CERCLA ID# VA8800010763

1.2 STATEMENT OF BASIS AND PURPOSE

This decision document presents the Selected Remedy for OU 8, the FUDS Skeet Range Munitions Response Site (MRS). The Skeet Range MRS is located at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) Wallops Flight Facility (WFF) in Accomack County, Virginia. The Selected Remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, 42 United States Code (USC) Section 9601 et seq., and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Part 300. This decision is based on the Administrative Record file for WFF.

NASA has selected the remedy, and the Virginia Department of Environmental Quality (VDEQ) and United States Environmental Protection Agency (USEPA) concur with the Selected Remedy.

1.3 ASSESSMENT OF SITE

NASA has determined that soil and sediment removal and off-site disposal is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. No action for surface water or groundwater is necessary to protect public health or welfare or the environment.

1.4 DESCRIPTION OF SELECTED REMEDY

The Skeet Range MRS is one of the sites identified under the FUDS program at NASA WFF. The Department of Defense (DoD) and NASA have executed a Memorandum of Agreement (MOA) under which NASA is the lead agency for implementing CERCLA actions at NASA WFF for FUDS (NASA, 2015). This Record of Decision (ROD) only applies to the Skeet Range MRS, and will be the sixth formal ROD processed of the 13 OUs. The remaining OUs are still in the Remedial Investigation (RI) phase. Separate investigations and assessments are being conducted for the other FUDS in accordance with an Administrative Agreement and Order on Consent between NASA and the EPA (USEPA, 2021).

Previous investigations have identified the presence of lead and polycyclic aromatic hydrocarbons (PAHs) in soil and sediment that pose an unacceptable risk to human health and the environment. Based on the results of the human health risk assessment (HHRA) and the ecological risk assessment (ERA), contaminated surface soil and sediment containing lead present a moderate to high ingestion risk to human and ecological receptors. Lead exposure from soil/sediment at the Skeet Range MRS is the only source of

lead at the OU. There are no unacceptable human health or ecological risks associated with surface water and groundwater.

The Selected Remedy is Alternative 2 – Soil and Sediment Removal and Off-Site Disposal. The Selected Remedy addresses source material that constitutes low-level threat wastes. The major components associated with the Selected Remedy, Soil and Sediment Removal and Off-Site Disposal, are as follows:

- Sampling of soil/sediment for off-site disposal requirements,
- Stabilization of soil and sediment prior to excavation as needed to convert it into non-hazardous waste,
- Excavation of approximately 5,890 cubic yards (CY)/ 8,830 tons of contaminated soil/sediment,
- Off-site disposal of excavated soil/sediment,
- Post-excavation confirmation soil/sediment sampling,
- Backfill of the excavated areas with 5,900 CY of clean fill material, and
- Ground cover restoration.

1.5 STATUTORY DETERMINATIONS

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

The Selected Remedy for the Skeet Range MRS does not satisfy the statutory preference for treatment as a principal element of the remedy for the following reasons: (1) principal threat material is not present at the Site, and (2) contaminated materials/waste at the Site are contained, are non-mobile, and are of low to moderate toxicity.

Because the Selected Remedy will not result in site-related hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure, a five-year review will not be required for this remedial action.

1.6 ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this ROD:

- ✓ Chemicals of concern (COCs) and their respective concentrations.
- ✓ Baseline risk represented by the COCs.
- ✓ Cleanup levels established for COCs and the basis for these levels.
- ✓ How source materials constituting principal threats are addressed.
- ✓ Current and reasonably anticipated future land use assumptions used in the baseline risk assessment and ROD (See Section 2.6 Current and Potential Future Land and Resource Uses).
- ✓ Potential land use that will be available at the site as a result of the Selected Remedy.
- ✓ Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected.
- ✓ Key factor(s) that led to selecting the remedy.

Additional information can be found in the Administrative Record file for this Site.

1.7 AUTHORIZING SIGNATURES

David Reth

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David A. Reth, Director
Management Operations
Goddard Space Flight Center

Date

PAUL LEONARD

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Paul Leonard, Director
Superfund & Emergency Management Division
USEPA Region 3

Date

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2.0 DECISION SUMMARY

2.1 SITE NAME, LOCATION, AND DESCRIPTION

WFF is located in northeastern Accomack County, Virginia. The facility is comprised of three separate areas: Main Base, Wallops Island, and Wallops Mainland (Figure 2-1). The Skeet Range MRS is located on the northern portion of the Main Base (Figure 2-2). The Main Base is situated on the Atlantic Coast of the Delmarva Peninsula approximately 5 miles south of the Maryland/Virginia state boundary, and just to the west of Chincoteague Island. The Main Base is comprised of 2,230 acres and is bounded by Little Mosquito Creek to the north, northwest, and northeast, Route 175 to the south, Simoneaston Bay and the Chincoteague Wildlife Refuge to the east, and the Chincoteague Bay Field Station, farms and residences, and Wattsville Branch to the west. Wallops Island and Wallops Mainland are located approximately 7.5 miles southeast of the Main Base.

The Skeet Range MRS was investigated under the United States Army Corps of Engineers (USACE) FUDS program. In 2015, NASA and the DoD, through the Department of the Army, negotiated and signed a MOA delegating CERCLA response action authority for the FUDS Program at NASA WFF to NASA under the CERCLA ID# VA8800010763 (NASA, 2015). Under the agreement, the DoD will continue to fund the FUDS Program and NASA will be responsible for implementing the program. NASA is now the lead agency for site activities at WFF. USEPA is the lead regulatory agency, and VDEQ is the support agency. Funding is provided through the USACE. Skeet Range MRS soil and sediment are addressed by this ROD. There are no surface water bodies within or immediately adjacent to the Skeet Range MRS.

The Skeet Range MRS is a part of the larger former Main Base Firing Range (MBFR) Complex consisting of 40 acres and several other ranges. The MBFR Complex includes the former Pistol Range, former Rifle Range, former Aircraft Gun Testing Range (AGTR), and finally the Skeet Range MRS.

The buildings and shooting stations associated with the MBFR Complex no longer exist. The MBFR Complex is in a secured industrial area adjacent to WFF's active airfield and the National Oceanic and Atmospheric Administration's (NOAA) operational antennae towers. Access is very limited due to operations. There are no residences or offices in this area. Current land use is classified as industrial, and the land use is expected to remain industrial in the future. All exposure areas at the site overlap partially with cultural resources restricted areas.

The NOAA operates their Command and Data Acquisition Station at WFF in a compound leased from NASA east of the MBFR Complex (Figure 2-1). This facility ensures scheduled data flow from NOAA satellites. The compound is enclosed by a chain link fence and drainage swales. The soil was reworked along this boundary as the compound expanded over the years. The NOAA facility is not included in the exposure areas because the ground surface has been significantly reworked since the Skeet Range MRS was last operational.

The RI for the Skeet Range MRS divided the site into four exposure areas for purposes of discussion and evaluation (Figure 2-2):

- High Tower Range Exposure Area
- Southern Range Exposure Area

- Northern Range Exposure Area
- Skeet Range Shooting Exposure Area

The High Tower Range Exposure Area is north and northwest of the NOAA facility and comprises two portions of the former High Tower Range that are outside of the NOAA facility and were not addressed by the non-time-critical removal actions (NTCRAs) in 2016 for the former AGTR, Pistol Range, and Rifle Range. The High Tower Range Exposure Area is old field grasslands and deciduous scrub.

The Southern Range Exposure Area is west and southwest of the NOAA facility and encompasses the southern portion of the former east-facing skeet range. This includes the area cleared by NOAA in 2011 during antennae tower construction (now a loblolly pine forest) and a flat grassy area (mowed). The Skeet Range Shooting Exposure Area is within the Southern Range Exposure Area.

The Northern Range Exposure Area is north of the NOAA facility and encompasses the northern portion of the former east-facing skeet range. The Northern Range Exposure Area is almost entirely a drainage swale of deciduous scrub leading to a palustrine forested wetland. The drainage swale conveys runoff north through the wetland to Little Mosquito Creek. A culvert located on the NOAA facility connects the southern and northern portions of the east-facing Skeet Range.

The Skeet Range Shooting Exposure Area is the area of the firing line and shooting stations of the former east-facing skeet range within the Southern Range Exposure Area

2.2 SITE HISTORY AND ENFORCEMENT ACTIONS

2.2.1 Site History

The Department of the Navy began purchasing land for the Chincoteague Naval Auxiliary Air Station (CNAAS) in 1942 through condemnation in order to establish the CNAAS as a training facility for World War II naval aviators. Prior to being developed for the CNAAS, the land principally consisted of farmland and marshes. Historical aerial photographs show that various buildings and three runways had been constructed by 1943.

On January 26, 1946, the Naval Aviation Ordnance Test Station was established on the Wallops Island portion of CNAAS. The former CNAAS was transferred to NASA on June 30, 1959. NASA identified this Station as Wallops Station from 1959 to 1974. In 1975, Wallops Station was renamed Wallops Flight Center. In October 1981, Wallops Flight Center was consolidated with the Goddard Space Flight Center in Maryland, and the name was officially changed to WFF. Since then, WFF has become NASA's primary facility for suborbital programs and is home to the Mid-Atlantic Regional Spaceport.

The Skeet Range MRS comprises two former skeet range configurations. The first skeet range—called either the Shotgun Range or High Tower Range—was constructed in 1944 with a northeast direction of fire. Sometime between 1945 and 1948, the High Tower Range was replaced with a reconfigured skeet range with an east direction of fire: The east-facing skeet range (Figure 2-2). Collectively these are the Skeet Range MRS and are the remaining areas of the MBFR Complex to be addressed under CERCLA. Most of the original High Tower Range is overlapped by the former east-facing skeet range, Rifle Range, Pistol Range, and AGTR.

The AGTR was constructed in 1944 after the completion of the airfield runways; it was converted into the Pistol Range in 1948. The Rifle Range was constructed adjacent to the Pistol Range in 1951. Records indicated use of the Pistol and Rifle Ranges continued through 1992, with minor usage until the ranges were officially closed in October 1999. The AGTR, Pistol Range, and Rifle Range were investigated and addressed previously by NTCRAs, which included soil excavation and off-site removal, in 2016.

2.2.2 Previous Investigations, Removal Actions, and Enforcement Actions

In 2007, a Site Inspection (SI) was performed as the initial investigation at the MBFR Complex (Tetra Tech, 2009a). The objectives were to characterize surface soil and shallow groundwater conditions, as well as potential drainage pathways. A habitat assessment also was conducted. Soil sampling was conducted at the east-facing skeet range (i.e., parts of the Northern and Southern Range Exposure Areas) for analysis of PAHs, pH, total organic carbon, metals, and grain size. Lead shot counts were also performed. Five shallow temporary monitoring wells were installed and sampled across the Complex. Two of the five wells were located within the Skeet Range MRS. They were installed and sampled for PAHs and metals. The report also included a human health risk screening.

In 2009, supplemental soil sampling efforts occurred in the Northern Range Exposure Area (Tetra Tech, 2009b). Surface soil samples from the drainage swale were collected and analyzed for lead. No lead shot was observed in these samples. Lead concentrations in the soil range from 325 to 1,400 milligrams per kilogram (mg/kg). The data summary report did not provide evaluation or conclusions.

In 2010, the USACE conducted a SI, which is a required step in USACE's FUDS program environmental restoration process, especially for sites known or suspected of containing unexploded ordnance (UXO), discarded military munitions, or munitions constituents (MC). The SI included records research, other desktop study elements, and munitions and explosives of concern (MEC) and MC evaluations; no fieldwork or environmental sampling was performed as part of the SI (USACE, 2012). The Remedial Project Manager (RPM) Team, which included NASA, USACE, USEPA, and VDEQ agreed that any potential MEC hazard at the Skeet Range MRS relates only to intact or unfired small arms munitions (which have a low explosive hazard). The records research identified the existence of the northeast-facing High Tower Range. The report summarized the site history, new records research, environmental investigation data collected to date and conclusions from the data, and the Munitions Response Site Prioritization Protocol rating. The report acknowledged the presence of MC and stated the absence of chemical warfare material. The report recommended an RI for the Skeet Range MRS, including the northeast-facing skeet range (i.e., High Tower Range Exposure Area) and drainage area (i.e., Northern Range Exposure Area).

In 2011, soil samples were collected and analyzed for total lead and Toxicity Characteristic Leaching Procedure (TCLP) lead analysis—from the eastern portion of the Southern Range Exposure Area—to support NOAA construction of two new antenna towers, which would encroach on the former east-facing skeet range. The soil lead concentrations from this NOAA-related sampling event ranged from 36.9 to 157 mg/kg, below the lead screening level of 400 mg/kg being used at that time. TCLP results from the event do not indicate hazardous characteristic lead levels (less than 5 milligrams per liter). NOAA has since cleared the trees and constructed two new antennae in this area

RI activities were performed at the site in 2018 through 2019 to meet the following objectives: further delineate the extent of contaminated surface soil; investigate potential contamination in subsurface soils; collect data to confirm contaminants of concern and develop preliminary remediation goals (PRGs) and reevaluate risk to human health and ecological receptors (NASA, 2020). Surface and subsurface soil

samples were collected in all the exposure areas and analyzed for lead. Samples in the Skeet Range Shooting Exposure Area were analyzed for PAHs. Surface soil was also sieved at many locations throughout the site to determine counts of lead shot, clay pigeon fragments, and grit particles.

No other enforcement activities, removal actions, or remediation activities have been initiated at the Skeet Range MRS.

2.3 COMMUNITY PARTICIPATION

The Proposed Plan for the Skeet Range MRS was made available to the public on April 3, 2023. A copy of the Proposed Plan was also sent to the seven Federally Recognized Tribes in Virginia. The Catawba Indian Nation reviewed the Feasibility Study (FS) (NASA, 2021) and had no concerns. The Proposed Plan and other documents, such as the RI report and FS can be found in the Administrative Record file and the Information Repositories maintained at the Eastern Shore Public Library (23610 Front Street, Accomac, Virginia 23301) and Island Library (4077 Main Street, Chincoteague, Virginia 23336). Selected technical documents for the Skeet Range, including the RI Report, Feasibility Study and Proposed Plan, are available to the public online at https://code200-external.gsfc.nasa.gov/250-WFF/operable-unit-08. The notice of availability of the Proposed Plan was placed in the Eastern Shore News on March 31, 2023 and on their website from March 31, 2023 through April 7, 2023 (https://easternshorepost.com/). A public comment period was held from April 3, 2023 through May 3, 2023. A public information session was held on April 5 at the NASA Wallops Flight Facility Visitor Center. One public comment was received by email during the comment period as noted in the Responsiveness Summary section of this ROD.

2.4 SCOPE AND ROLE OF RESPONSE ACTION

The FUDS and other sites at NASA WFF have been divided into OUs by the USEPA to further address future investigations and remediation, and the Skeet Range MRS is designated as OU 8. The table below shows the full list of OUs and their status:

OU#	SITE NAME	STATUS
1	Scrapyard Site N-222	ROD in February 2008
2	Former Fire Training Area	Long-term Monitoring (LTM); ROD in December 2007
3	Waste Oil Dump	LTM; ROD in March 2008
4	Site 9 Abandoned Drum Dump	ROD in April 2021
5	Site 14 and 15 Debris Piles	ROD in FY25
6	Old WWTP	ROD in September 2022
7	Construction Debris Landfill	RI/FS
8	Skeet Range	ROD in FY24
9	Boat Basin and Visitor's Center	RI/FS
10	PFAS – Main Base East	RI
11	PFAS – Main Base North	RI
12	PFAS – Main Base Central	RI
13	PFAS – Wallops Island	RI

This ROD deals only with the WFF FUDS Skeet Range MRS and does not include or affect any other site or OU. The Skeet Range MRS is one of multiple sites at WFF being addressed under CERCLA. This ROD applies only to soil and sediment. There are no surface water bodies within or immediately adjacent to the Skeet Range MRS, and no action is required for groundwater.

The Selected Remedy is the final remedial action for soil and sediment at the Skeet Range MRS under CERCLA.

The scope and role of the response action for the Skeet Range MRS is to reduce risks to human health and the environment associated with exposure to contamination in soil and sediment at the Skeet Range MRS, which is a low-level threat waste. NASA has determined that Soil and Sediment Removal and Off-Site Disposal is necessary for the protection of ecological and human receptors. Through excavation and off-site disposal of soil and sediment, the Selected Remedy will address all known and potential ecological and human health risks associated with soil and sediment at the Skeet Range MRS.

2.5 SITE CHARACTERISTICS

2.5.1 Physical Setting

NASA WFF is located on the Eastern Shore of Virginia within the Atlantic Coastal Plain physiographic province. The geology of the Eastern Shore of Virginia can be characterized as a series of layered, unconsolidated, sedimentary units deposited in the Salisbury Embayment (Meng and Harsh, 1988). The sediments comprise an eastward-thickening wedge that dips to the northeast towards the Atlantic Ocean. In the vicinity of the NASA WFF, approximately 7,000 feet of sediment lie atop crystalline basement rock. The two stratigraphic groups encountered at the WFF are the Chesapeake Group and the overlying Columbia Group.

The MBFR Complex is located on the northern side of the Main Base, east of Runway 17-35, on a peninsula-like feature adjacent to Little Mosquito Creek. The southern half and the central portion of the MBFR Complex, generally coinciding with the former Rifle and Pistol Ranges, is mostly grassy and flat, with little slope. The perimeter of the MBFR Complex consists of gentle slopes ranging from 1 to 4 percent to the northwest, north, and east. There are no streams within or adjacent to the MBFR Complex and drainage is via overland sheet flow. Southern and eastern downrange portions of the former east-facing skeet range drain into a centralized collection area where surface runoff is directed through a concrete drainage culvert, to the Northern Range Area. The Northern Range Area consists of a drainage swale that discharges water to Little Mosquito Creek and associated wetlands. Little Mosquito Creek is located about 400 feet to the north of the MBFR Complex. Vegetation on the northern and eastern portions of the site consists of conifers, bushes, and tall grasses. The MBFR Complex area is undeveloped, and the Facility Master Plan indicates that the area will remain undeveloped because of building height and occupancy restrictions. These restrictions are in place due to the close proximity of the active airport runways, which are important to the facility mission.

At WFF the surficial geology can be characterized as a silty fine-grained sand with varying amounts of clay and gravel. The thickness of this silty fine-grained sand varies but can be as thick as 15 feet or absent altogether. Below the silty fine-grained sand is a more coarse well sorted fine to medium-grained sand. Most soil encountered at the Skeet Range MRS during the investigations was silty fine-grained sand with varying amounts of organics and trace amounts of medium to coarse-grained sand.

The local aquifer system at the WFF consists of four aquifers: the upper, middle, and lower Yorktown-Eastover aquifers and the Columbia aquifer (also called the "surficial" aquifer). These aquifers serve as the primary source of water for public and domestic supplies and for agricultural and industrial uses. The hydrogeologic framework is derived from Hydrogeology and Analysis of the Ground-Water-Flow System of the Eastern Shore, Virginia (Richardson, 1994).

The Columbia Group extends to a subsurface depth of approximately 60 feet and consists of interbedded sands, gravels, and sandy clays deposited under fluvial and marine conditions. The Columbia Group is overlain by a variably thin (generally about 5 feet) veneer of recent deposits composed chiefly of wind-deposited or fluvial sands, silts, and gravels. Within the Columbia aquifer there are a series of clay, silt, and/or sandy clay lenses. These lenses are not continuous and do not act as a confining layer but do impede vertical flow locally. The water table beneath the WFF typically occurs under unconfined conditions within the recent deposits and Columbia Group at depths of 0-to-30-feet below ground surface (bgs) (Occu-Health, 1999) and groundwater flow generally mimics topography (Tetra Tech, 2004).

The MBFR Complex is located in a secured industrial area (NASA and NOAA) adjacent to an active airfield and operational antennae towers. Access is very limited due to operations. There are no residences or offices in this area. Current land use is industrial and the land use is expected to remain industrial in the future.

The southern half of the Skeet Range MRS is mostly flat, with little slope. However, along the northern, eastern, and northwestern boundaries of the study area, steep slopes direct surface runoff into low-lying marshes that border Little Mosquito Creek. Approximately 300 to 500 feet of marshland separates Little Mosquito Creek from the MBFR Complex to the north and east. There are no surface water bodies within or immediately adjacent to the MBFR Complex.

The habitats at the MBFR Complex consist primarily of overgrown vegetation, including grasses, shrubs, and trees. The only wetland habitat is situated in the downstream reaches of the drainage swale located north of the NOAA facility. This wetland is best described as a palustrine forested wetland.

2.5.2 Human Health and Ecological Conceptual Site Models

Figure 2-7 presents the Conceptual Site Model (CSM) for human receptors at the Skeet Range MRS, while Figure 2-8 presents the ecological CSM. The CSM graphically integrates information regarding the physical characteristics of the Site, exposed populations, sources of contamination, and contaminant mobility (fate and transport) to identify potential exposure routes and receptors evaluated in the risk assessment. A well-defined CSM allows for a better understanding of the risks at a site and aids in the identification of the potential need for remediation.

2.5.3 Sampling Strategy

Field activities for the RI at the Skeet Range MRS were carried out in March, April, and December 2018, as well as in March 2019. Multiple events were required to assess, plan, and evaluate the extent of lead, PAH, and lead shot contamination. These field events were designed to further characterize the nature and extent of contamination, gather data to evaluate the risk to human health and ecological receptors, and support future corrective action decisions at the Skeet Range MRS. The RI fieldwork did not include sampling groundwater because the SI Report recommended that no further evaluation of groundwater was necessary. The RI fieldwork did not include surface water sampling because there are no surface water

locations within or immediately adjacent to the Skeet Range MRS. The field activities conducted during the RI are summarized below.

March 2018

- Collected surface and subsurface soil samples for lead analysis at 56 locations and PAH analysis at 22 locations.
- Surface and subsurface soils were sieved using a #10 sieve (2-millimeter [mm] mesh size) at 33 locations and a #35 sieve (0.5-mm mesh size) at two locations.
- Lead shot, non-lead grit sized particles, and clay pigeon fragments from the sieved fractions were counted.

April 2018

- Wetlands delineation in the Northern Range Area.

December 2018

- Collected surface soil samples for lead analysis at 9 locations and PAH analysis at 3 locations.
- Surface and subsurface soils were sieved using a #10 sieve at 29 locations and a #20 sieve (0.85-mm mesh size) or a #14 sieve (1.4-mm mesh size) at 14 locations.
- Lead shot, non-lead grit sized shot particles, and clay pigeon fragments from the sieved fractions were counted.

March 2019

- Surface and subsurface soils were sieved using a #10 sieve at 29 locations and a #14 sieve at 7 locations.
- Lead shot, non-lead grit sized particles, and clay pigeon fragments from the sieved fractions were counted.

2.5.4 Nature and Extent of Contamination

The lead, PAH, and lead shot results in surface and subsurface soil at the Northern Range Area, Southern Range Area, High Tower Range Area, and Skeet Range Shooting Area were screened against PRGs. PRGs were developed based on the evaluation of the risk to human health and ecological receptors. Human health PRGs were established to protect hypothetical residents and industrial workers from lead and target PAHs in soil; soil/sediment is the only source of exposure to lead at the OU. Ecological PRGs were established to protect plants and birds from concentrations of lead in soil and to protect birds from lead shot in the soil.

PRGs were initially developed in the RI SAP (Tetra Tech, 2018a) and RI Report (Tetra Tech, 2020) and derived through the identification of chemical-specific ARARs and TBCs applicable to lead, PAHs, or lead shot in soil or sediment. Human health risk-based PRGs were developed by calculation of an acceptable risk using TBCs (e.g., toxicity reference values or lead modeling) to back calculate for each medium and COC. PRGs are considered for all media of concern and all exposure scenarios with unacceptable risks for both current and, in this case, hypothetical future land use scenarios. The new EPA residential lead guidance was also used to compare as a chemical specific TBC (USEPA, 2024).

Ecological risk-based PRGs were developed for plants and birds for exposure to lead in soil, and for sediment invertebrates from exposure to lead in sediment. In addition, ecological risk-based PRGs were developed for birds from exposure to lead shot in soil. The development of the PRGs for plants, birds (from exposure to lead in soil), and sediment invertebrates were presented in a technical memorandum that was an appendix to the RI SAP (Tetra Tech, 2018a).

The technical memorandum also presented an initial PRG for birds from exposure to lead shot in soil of 10 lead shot pellets/ft^2 which was refined to 100 lead shot pellets/ft^2 after the collection of additional sieve/lead shot counts and ingestion probability modeling in the ERA in the RI Report (Tetra Tech, 2020). The probability model in the USEPA Assessment of Methods for Estimating Risk to Birds from Ingestion of Contaminated Grit Particles (Bennett et al., 2011) was used to evaluate risks to birds from ingesting lead shot. The model uses the number of lead shot and non-lead particles (i.e., sand, gravel, rocks) to calculate the probability for birds to ingest a lead particle from the site using site-specific parameters. The model includes a spreadsheet that was used to calculate the probability for birds to ingest a lead particle from the site using site-specific parameters. The RI report presets the parameters used in the model that were modified for the mourning dove and using site-specific values for estimating probability of ingesting lead particles. More details are provided in the RI report but in summary, with the exception of 94 lead shot/ft^2 in one sample, the probability of ingesting lead shot was less than 20 percent when 100 or fewer lead shot were present in a sample (based on non-lead particles retained on the No. 14 sieve). That is the basis for the PRG of 100 lead shot pellets/ft^2. Note that the 100 lead shot pellets/ft^2 was not defined as the PRG until the FS (Tetra Tech, 2021). All background values are less than the proposed PRGs. PRGs for each contaminant are presented below.

2.5.4.1 Surface Soils and Sediment

Surface soils are defined as being from the ground surface to 1-foot bgs for the evaluation of nature and extent of contamination. In Section 7 – Human Health Risk Evaluation and Section 8 – Ecological Risk Assessment, surface soils are defined as the top 6 inches of soil (0 to 6 inches). The top 6 inches represents the greatest risk to receptors and provides the most conservative scenario. Figures 2-3 through 2-6 show soil and sediment sample locations and exceedances from previous investigations for all four Skeet Range MRS areas.

Lead

Lead analysis was performed on 69 surface soil samples at the Skeet Range MRS during the 2009 SI sampling, 2009 follow-up soil sampling, and the 2011 NOAA sampling. During the RI an additional 130 surface soil samples were collected and analyzed for lead.

Lead surface soil samples were collected from the Northern Range Area, Southern Range Area, and High Tower Range Area. Lead concentrations above the human health and/or ecological PRGs are present in surface soil samples from the Northern Range Area and Southern Range Area.

In the High Tower Range Area, lead concentrations were below the not-to-exceed ecological PRG of 750 mg/kg but above the human health PRG of 200 mg/kg. The maximum lead concentration was 508 mg/kg at SR-SS-254. The arithmetic average for lead in the High Tower Range Area is 115 mg/kg for the 0-to-6-inch interval and 52 mg/kg for the 6-to-12-inch interval (Figure 2-3).

In the Southern Range Area, lead concentrations above the not-to-exceed human health PRG of 200 mg/kg and the ecological PRG of 750 mg/kg are present in the flat area approximately 400 feet away from the shooting area positions. These samples form a thin ribbon that extends from SR-SS-230 to SR-SS-235 before getting cut-off by the NOAA fence line. Soil samples collected around the satellite antennae towers showed lead concentrations below the ecological PRG, likely due to this area being reworked. The maximum lead concentration in the Southern Range Area was 1,140 mg/kg at SR-SS-235 from 0-to-6 inches. The arithmetic average for lead in the Southern Range Area is 196 mg/kg for the 0-to-6-inch interval and 86 mg/kg for the 6 to 12-inch interval (Figure 2-4).

In the Northern Range Area, lead concentrations above the not-to-exceed human health PRG of 200 mg/kg and the ecological PRG of 530 mg/kg are present in the drainage swale. There is some uncertainty in whether the low-lying soil/sediment samples at the Northern Range Area provide habitat for sediment invertebrates and therefore they will be evaluated as sediment samples to be conservative. These samples form two clusters of exceedances located in the low-lying areas of the drainage swale that conveys runoff from the east facing skeet range to Little Mosquito Creek. The larger cluster is comprised of SR-SS-037, -100, -102, -103, -105, -106, -201, -202, and -213; while the smaller cluster is located to the north and consists of SR-SS-108. The maximum lead concentration of 22,200 mg/kg was detected at SR-SS-213 from 0 to 6 inches, with the next highest concentration being 2,020 mg/kg at SR-SS-202 from 0 to 6 inches. The arithmetic average for lead in the Northern Range Area is 1,112 mg/kg for the 0-to-6-inch interval and 185 mg/kg for the 6-to-12-inch interval. If the highest detection of 22,200 mg/kg that is orders of magnitude higher than all other samples is removed, the average drops to 510 mg/kg. (Figure 2-5).

PAHs

PAH analysis was performed on 54 surface soil samples at the Skeet Range MRS during the 2009 SI sampling and 2009 follow-up soil sampling. An additional 30 surface soil samples were collected in the Skeet Range Shooting Area for PAH analysis during the RI.

Seven PAHs were identified in the SAP and were screened against the human health PRG (total point risk of 1x10-4). Figure 2-6 presents the data and the areas with total point risk greater than 1x10-4 appear to form clusters in the Skeet Range Shooting Area specifically along the firing line (11 sample locations) and south of the firing line (SR-SS-275 and -276). Thirteen samples were from the 0-to-6-inch interval and one sample was from the 6 to 12-inch interval. The highest total point risk was in samples from SR-SS-267 (7.1x10-4) and SR-SS-275 (7.0x10 4), both in the 0-to-6-inch interval.

Lead Shot

Lead shot counts were made during the 2009 SI sampling (56 surface soil samples) and during the RI (142 surface soil samples). The Northern Range Area was investigated for lead shot during the SI sampling but not during the RI because lead shot was not found in any of the four SI samples.

In the Southern Range Area, the majority of the lead shot was found in the 0-to-6-inch interval on the flat grassy portions (southern half of the Southern Range Area) or along the fence line that divides NASA and NOAA. In the 0-to-6-inch and 6-to-12-inch intervals, lead shot greater than 100 lead shot/ft2 was found at 20 locations and two locations, respectively. These samples encompassed the same area as the samples which had lead concentrations greater than the not-to-exceed PRG, however, elevated lead shot has a slightly larger footprint. The greatest lead shot counts were found at SR-SS-235 at 967 lead shot/ft2 in the 0-to-6-inch interval. The non-lead grit sized particle counts are included for the #10, #14, #20, and #35

sieved fractions, which were used along with the lead shot counts to evaluate the ingestion probability by birds.

In the High Tower Range Area, the majority of the lead shot was found in the 0-to-6-inch interval in the southeastern portion. In the 0-to-6-inch and 6-to-12-inch intervals, lead shot greater than 100 lead shot/ft2 was found at 13 locations and two locations, respectively. The greatest lead shot counts were found at SR-SS-256 at 359 lead shot/ft2 in the 0-to-6-inch interval. The non-lead grit sized particle counts are included for the #10, #14, #20, and #35 sieved fractions, which were used along with the lead shot counts to evaluate the ingestion probability by birds. Some samples with lead shot counts greater than 100 lead shot/ft2 were found in the western portion of the Northern Range Area.

In addition to the 2009 data, lead shot counts were performed on 35 subsurface soil samples during the RI. Most of the lead shot in both the Southern Range Area and High Tower Range Area was found in the 0 to 6-inch and 6 to 12-inch intervals. However, some lead shot was found in the 1 to 2-foot interval. The maximum lead shot counts in subsurface soil at the Southern Range Area was 45 lead shot/ft2 at SR-SS-220 from the 12 to 24-inch interval, which were less than the ecological PRG. Lead shot was not found in subsurface soil at the High Tower Range Area.

2.5.4.2 Subsurface Soils

Subsurface soils are defined as being as any soil deeper than 1-foot bgs for the evaluation of nature and extent of contamination. In Section 7 – Human Health Risk Evaluation and Section 8 – Ecological Risk Assessment subsurface soils are defined as any soil deeper than 6 inches.

Lead

Lead analysis was performed on 19 subsurface soil samples during the RI. The maximum lead concentration in subsurface soil was 140 mg/kg for the Northern Range Area, 191 mg/kg for the Southern Range Area, and 18.2 mg/kg in the High Tower Range Area. The arithmetic average for lead in subsurface soil was 57 mg/kg for the Northern Range Area, 30 mg/kg for the Southern Range Area, and 10 mg/kg in the High Tower Range Area, all below the established PRG of 200 mg/kg.

PAHs

PAH analysis was performed on eight subsurface soil samples at the Skeet Range Shooting Area during the RI. PAH concentrations in subsurface soil are generally low with a maximum concentration of any PAH of 13.9 mg/kg, which is less than the PRG total point risk of 2.6x10 -6.

Lead Shot

Lead shot counts were performed on 35 subsurface soil samples during the RI.

Most of the lead shot in both the Southern Range Area and High Tower Range Area was found in the 0-to-6-inch and 6-to-12-inch intervals. However, some lead shot was found in the 1- to 2 foot interval. The maximum lead shot counts in subsurface soil at the Southern Range Area was 45 lead shot/ft2 at SR-SS-220 from the 12-to-24-inch interval. Lead shot was not found in subsurface soil at the High Tower Range Area.

2.5.5 Fate and Transport

Lead shot and lead have not been very mobile. The majority of the lead shot was found in the 0-to-6-inch interval, however, it was also found in the 6- to 12-inch interval and to a much lesser degree in the 1-to-2-foot interval. The lead shot was generally in good condition with little fragmentation or oxidation. Lead appears to be limited to the first one to three inches of soil and has not migrated significantly to subsurface soil or groundwater. Subsurface lead concentrations are less than the human health and ecological PRGs and lead was not detected in the groundwater.

PAHs are bound to the clay pigeon fragments and are not readily soluble. The clay pigeon fragments were almost exclusively found at the surface in the 0-to-6-inch interval. The clay pigeon fragments ranged in size but were generally competent. Elevated concentrations of PAHs were mostly found in the 0-to-6-inch interval, however, a select few 6- to 12-inch intervals also had elevated PAH concentrations. The 1-to-2-foot intervals had very low concentrations of PAHs, signifying that PAHs are not migrating into subsurface soils or groundwater.

The potential contaminant migration pathways at the Skeet Range MRS consist of the following:

- Migration of lead and PAHs from surface to subsurface soils.
- Migration of lead and PAHs via surface soil runoff or erosion.

2.6 CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

The buildings and shooting stations associated with the MBFR Complex no longer exist. The MBFR Complex is in a secured industrial area adjacent to WFF's active airfield and NOAA operational antennae towers. Access is very limited due to operations. There are no residences or offices in this area. Current land use is classified as industrial, and the land use is expected to remain industrial in the future. All exposure areas at the site overlap partially with cultural resources restricted areas and there are no unacceptable risks associated with exposure to groundwater.

2.7 SUMMARY OF SITE RISKS

The baseline risk assessment estimates what risks the site poses if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the results of the baseline risk assessment for this site.

2.7.1 Summary of Human Health Risk Assessment

A human health risk evaluation was conducted for the Northern Range Area, Southern Range Area (and overlapping Skeet Range Shooting Area), and High Tower Range Area at MBFR Complex Skeet Range MRS. The summary below was updated to account for changes in USEPA Regional Screening Levels (RSLs) and lead guidance published since the baseline human health risk assessment was completed during the RI.

2.7.1.1 Identification of Chemicals of Concern

Chemicals of Potential Concern (COPCs) were identified by comparing chemical concentrations in surface soil and subsurface soil to USEPA RSLs (USEPA, 2023). Cancer and non-cancer risk estimates were developed based on development of ratios of exposure point concentrations (EPCs) of COPCs in surface soil and subsurface soil to the RSLs for residential and industrial soil exposures. Risks from exposures to lead in soil were evaluated with the Integrated Exposure Uptake Biokinetic (IEUBK) and Adult Lead Methodology (ALM).

Lead was the only chemical detected at concentrations exceeding screening levels in surface soil and subsurface soil at the Northern Range Area (Table 2-4).

At the Southern Range Area/Skeet Range Shooting Area, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and lead were detected at concentrations exceeding screening levels in surface and subsurface soil, and benzo(k)fluoranthene was detected at concentrations exceeding the screening level in surface soil only (Table 2-4).

At the High Tower Range Area, only concentrations of lead in surface soil exceeded the screening levels. Concentrations of all chemicals in subsurface soil were below screening levels (Table 2-4).

A summary of the final chemicals of concern is shown on Table 2-1. Human health residential and industrial summaries are located in Table 2-2 and 2-3 respectively.

2.7.1.2 Exposure Assessment

The compilation of contaminant sources, likely exposure pathways, and receptors at the Skeet Range MRS are depicted in the Human Health CSM (Figure 2-7)

Potential receptors due to unacceptable risk of lead in surface soil and subsurface soil at the Northern and Southern Range Exposure Areas, and only in surface soil at the High Tower Range Exposure Area, include hypothetical industrial workers and residents. Potential receptors due to unacceptable risk of PAHs in surface soil at the Southern Range Exposure Area and Skeet Range Exposure Area include hypothetical residents only. Exposure routes for lead and PAHs in soil include dermal contact, ingestion, and potential inhalation from fugitive dusts.

Major assumptions about exposure frequency (days per year), exposure duration (years), and other exposure factors (e.g., body surface area for dermal exposure, ingestion rates) that were included in the exposure assessment can be found in the RI Report (NASA, 2020).

2.7.1.3 Toxicity Assessment

In this risk evaluation, toxicity values were already incorporated into the RSLs. The assumption that exposure at the site is equivalent to the exposure used to derive the RSLs precluded the need to outline the toxicological indices for each COPC. Oral reference doses (RfDs), cancer slope factors (CSFs), inhalation reference concentrations (RfCs), and inhalation unit risks (IURs) used in this human health risk evaluation are included in the tables mentioned above and were obtained from the following primary USEPA recommended literature sources and following hierarchy (USEPA, 2003b):

- Tier 1 - Integrated Risk Information System (IRIS).

- Tier 2 - USEPA Provisional Peer Reviewed Toxicity Values (PPRTVs) – The Office of Research and Development/National Center for Environmental Assessment (NCEA) Superfund Health Risk Technical Support Center develops PPRTVs on a chemical-specific basis when requested by USEPA's Superfund program.
- Tier 3 - Other Toxicity Values – These sources include but are not limited to California Environmental Protection Agency (Cal EPA) toxicity values, Agency for Toxic Substances and Disease Registry (ATSDR) values, and the Health Effects Assessment Summary Tables (HEAST).

Although RfDs and CSFs can be found in several toxicological sources, USEPA's IRIS online database is the preferred source of toxicity values. The values presented in IRIS have been verified by the agency's consensus peer review process.

The PAH COCs have toxicity data indicating their potential for carcinogenic health effects on humans by oral/dermal and inhalation pathways.

One PAH COC, benzo(a)pyrene, also has toxicity data indicating a potential for adverse non-carcinogenic health effects on humans by the oral/dermal and inhalation pathways.

As yet, USEPA has not derived an RfD or RfC for lead. Although USEPA considers lead a probable human carcinogen (weight of evidence classification B2, with sufficient evidence in animals but inadequate evidence in humans), USEPA has not estimated a CSF for lead. The noncarcinogenic effects, however, are generally considered of greatest concern. Because there are no toxicity criteria for lead, the methodology used to estimate potential risks from lead is different than the approach for other chemicals, and lead was evaluated separately as discussed in Section 2.7.1.4.

2.7.1.4 Human Health Risk Characterization

The risk ratio approach was used to calculate cancer risks and hazard indices to be consistent with the methodology used in the SI Report. Exposure assumptions used in the risk ratio approach are default EPA exposure assumptions and are the same exposures that would be used in a traditional risk assessment; therefore, the risks would be the same. Receptors evaluated in the SI Report included residents and industrial workers. The same receptors were evaluated in this risk assessment to be consistent with the SI report. Construction workers are also potential receptors at the site. Potential risks to construction workers would be comparable or less than those of industrial workers; therefore, construction workers were not evaluated in this risk assessment.

Risks from COPCs were calculated for carcinogenic and non-carcinogenic effects. This was accomplished by performing a ratio comparison to the USEPA RSLs for residential and industrial land use for soils. Lead risks were evaluated independently by estimating potential blood lead levels using the IEUBK model and the ALM.

Non-carcinogenic risk estimates are presented in the form of HQs. The HQ was derived by dividing the non-carcinogenic RBC for a particular medium (e.g., soil) into the EPC. The USEPA RSLs were used as the RBCs in this evaluation. Compounds potentially resulting in non-carcinogenic (systemic) effects will be evaluated using the following equations:

$$HQ_i = \frac{C_i}{RBC}$$

$$HI = \sum_{i=1}^{n} HQ_i$$

Where:

HQ_i	=	Hazard quotient for compound i.
C_i	=	Exposure point concentration (mg/kg) for compound i.
RBC_i	=	Risk-based concentration (mg/kg) for compound i. The RBC is set equal to a hazard quotient of 1.
HI	=	Hazard index.

The HQs for all COPCs were summed to account for potential non-carcinogenic effects associated with multiple chemical exposures (i.e., the HI was calculated). The total hazard index (HI) was then compared to the USEPA's target level of 1. "Acceptable" exposure levels are generally concentration levels that represent a HI less than or equal to 1. However, because all chemicals do not exhibit the same mechanism of action or impact the same target organ, the exceedance of this value does not necessarily constitute an "unacceptable" non-carcinogenic risk. If the estimated HI was greater than 1, non-carcinogenic effects were segregated according to the affected target organs and target organ HIs were calculated, which represent the sum of those chemicals that impact similar target organs or exhibit similar mechanisms of action. Generally, estimated HIs greater than 1 for the same target organs are considered to be "unacceptable."

Carcinogenic risks are expressed in the form of dimensionless probabilities, referred to as incremental lifetime cancer risks (ILCRs). The ILCR was derived by dividing the carcinogenic RBC for a particular medium (e.g., soil) into the EPC. COPCs potentially resulting in carcinogenic effects were evaluated using the following equation:

$$\mathrm{ILCR} = \sum_{\mathrm{i}=1}^{\mathrm{n}} \left(\frac{\mathrm{C_i}}{\mathrm{RBC_i}} \times 10^{-6} \right)$$

Where:

ILCR	=	Incremental lifetime cancer risk.
C_i	=	Exposure point concentration (mg/kg) for compound i.
RBC_i	=	Risk-based concentration (mg/kg) for compound i. The RBC represents the 10^{-6} risk level.
10^{-6}	=	Risk assessment point of departure risk level.

Multiplying the C_i/RBC ratio by USEPA's point of departure risk level, $1x10^{-6}$, produces a cancer risk estimate for the detected COPC. The ratios are multiplied by $1x10^{-6}$ because the RBCs correspond to a $1x10^{-6}$ risk level. The ILCR values for all COPCs were summed to account for potential cumulative carcinogenic effects of multiple carcinogens detected in an environmental medium. The total ILCR was then compared to USEPA's target cancer risk range of $1x10^{-4}$ to $1x10^{-6}$, which is used to determine whether a potential for human health risk exists at a site. According to the USEPA, for known or suspected carcinogens, "acceptable" exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk between $1x10^{-4}$ to $1x10^{-6}$ or less than $1x10^{-6}$. A $1x10^{-4}$ ILCR estimate corresponds to the potential for the occurrence of one additional incidence of cancer in an exposed population of 10,000 individuals. Generally, an estimated ILCR greater than $1x10^{-4}$ is regarded as "unacceptable."

Some chemicals exhibit both carcinogenic and non-carcinogenic effects. The more restrictive USEPA RSL was used for selecting COPCs but both carcinogenic and non-carcinogenic risks were estimated. Cancer risks and hazard indices were estimated assuming industrial and hypothetical residential land use.

Risk Characterization for the Skeet Range MRS

Risks for COPCs in surface soil and subsurface soil at the Southern Range Area (and overlapping Skeet Range Shooting Area) were estimated using the above methodology, and are summarized in the following table. More complete summaries are also shown in Table 2-2 and Table 2-3. Lead was the only COPC identified in surface soil and subsurface soil at the Northern Range Area and High Tower Range Area. As discussed above, risks from exposures to lead in soil are evaluated with the IEUBK model and ALM. Consequently, cancer risks and HIs were not calculated for the Northern Range Area and High Tower Range Area.

Southern Range Area/Skeet Range Shooting Area

Area	Hazard Index		Cancer Risk	
	Residential	Industrial	Residential	Industrial
Surface Soil	0.5	0.04	$2x10^{-04}$	$8x10^{-06}$
Subsurface Soil	0.5	0.04	$1x10^{-04}$	$7x10^{-06}$

HIs for residents and industrial workers exposed to surface soil and subsurface soil at the Southern Range Area (and overlapping Skeet Range Shooting Area) were less than the target level of 1. Cancer risks for residents exposed to surface soil exceeded USEPA's target risk range of 10^{-4} to 10^{-6}, while cancer risks for residents exposed to subsurface soil were equal to the upper bound of the target risk range. Benzo(a)pyrene was the major contributor to the cancer risk, and several other PAHs also contributed cancer risks greater than $1x10^{-6}$. Cancer risks for industrial workers exposed to surface soil and subsurface soil were within USEPA's target risk range.

Risks from Lead

Lead was identified as a COPC in surface soil and subsurface soil at the Northern Range Area, surface and subsurface soil at the Southern Range Area, and surface soil at the High Tower Range Area. Concentrations of lead in subsurface soil at the High Tower Range Area were less than the residential screening level. Residential exposures to lead in soil were evaluated using USEPA's IEUBK lead model (2021). Exposures to lead in soil by industrial workers were evaluated using a slope factor approach developed by the USEPA Technical Review Workgroup (TRW) (USEPA, 2003a, 2017a).

Residential exposures to lead in surface soil and subsurface soil were evaluated using the most recent version of the IEUBK lead model (Version 2.0, Build 1.72). As recommended in USEPA guidance and the IEUBK Model documentation, the average lead concentration was used as the EPC for each of the exposure units (USEPA, 1994 and 2021). Also, as recommended by current guidance, the default age range of 12 to 72 months (USEPA, 2017b) was used in the IEUBK model.

A value of 5 micrograms per deciliter (µg/dL) was used as the acceptable blood lead level. Current scientific literature on lead toxicity indicates that adverse health effects are associated with blood lead levels below the long-held target of 10 µg/dL. Specifically, evidence exists of clear cognitive declines in young children

with blood lead levels between 2 and 8 µg/dL, as referenced in the December 2016 USEPA OLEM Memo (USEPA, 2016). For this reason, USEPA recommends consideration of current scientific conclusions when evaluating lead exposure (actual or potential) at CERCLA sites. Although an official policy is not currently in place, USEPA may draft a directive formally lowering of the target blood lead level in the future, resulting in a lower risk-based cleanup level for this metal. This, in turn, could trigger the need for re-evaluation of lead at sites that have not achieved the more protective standard.

IEUBK Model outputs are included in Appendix A, and results are summarized in the following table.

Lead Risks - Residential

Exposure Unit	Exposure Point Concentration (mg/kg)	Blood-Lead Geometric Mean Concentration (µg/dL)	Percent of Receptors Exceeding 5 µg/dL
Northern Range Area			
Surface Soil	1,107	7.10	77.2
Subsurface Soil	170	2.13	3.45
Southern Range Area			
Surface Soil	190	2.25	4.43
Subsurface Soil	84.2	1.61	0.785
High Tower Range Area			
Surface Soil	117	1.81	1.52

The results for residents exposed to lead in surface soil at the Northern Range Area exceed the USEPA goal of no more than 5 percent of children exceeding a 5 µg/dL blood lead level. The results for residents exposed to lead in subsurface soil at the Northern Range Area, surface soil and subsurface soil at the Southern Range Area, and surface soil at the High Tower Range Area do not exceed the USEPA goal of no more than 5 percent of children exceeding a 5 µg/dL blood lead level.

Exposures to lead in surface soil and subsurface soil by industrial workers were evaluated using ALM developed by the USEPA TRW for Lead (USEPA, 2003a, 2017a). As recommended in the ALM documentation, the average lead concentrations in surface soil and subsurface soil were used as the EPCs at each of the EUs. ILCRs and HIs are calculated for non-lead chemicals using reasonable maximum exposure (RME) assumptions; however, the ALM guidance recommends the use of central tendency exposure (CTE) assumptions in evaluating adult exposures to lead in soil (USEPA, 2003a). Therefore, the incidental soil ingestion rate was assumed to be 50 mg/day and the exposure frequency was assumed to be 219 days per year for the industrial worker. Default parameters were used for the remaining model input parameters. Results of the model runs are included in Appendix A. The fetus of a pregnant worker is the ultimate receptor of concern for the ALM. The results of the modeling are shown below.

Lead Risks - Industrial

Exposure Unit	Exposure Point Concentration (mg/kg)	Blood-Lead Geometric Mean Concentration (µg/dL)	Percent of Receptors Exceeding 5 µg/dL
Northern Range Area			
Surface Soil	1,107	2.2	5.70
Subsurface Soil	170	0.8	0.07
Southern Range Area			
Surface Soil	190	0.9	0.08
Subsurface Soil	84.2	0.7	0.03
High Tower Range Area			
Surface Soil	117	0.8	0.04

The results for industrial workers exposed to lead in surface soil at the Northern Range Area exceed the USEPA goal of no more than 5 percent of children (fetuses of exposed women) exceeding a 5 µg/dL blood-lead level. The results for industrial workers exposed to lead in subsurface soil at the Northern Range Area, surface soil and subsurface soil at the Southern Range Area, and surface soil at the High Tower Range Area do not exceed the USEPA goal of no more than 5 percent of children (fetuses of exposed women) exceeding a 5 µg/dL blood-lead level.

Uncertainty Analysis

The following sources of uncertainty should be considered when interpreting the results of this human health risk evaluation.

- COPC selection was based on USEPA RSLs for residential land use and correspond to ILCRs of 1x10-6 and HIs of 0.1. The use of the RSLs ensured that all the significant contributors to risk from a site were evaluated. The elimination of chemicals present at concentrations that correspond to ILCRs less than 1x10-6 and HIs less than 0.1 should not affect the final conclusions of the risk assessment because those chemicals were not expected to cause a potential health concern to residential receptors at the detected concentrations.
- In this risk ratio evaluation, a primary source of uncertainty regarding potential soil exposure is the assumption that future residents would live at the site. Future residential development at the site is not anticipated based on current land use, and NASA plans to maintain the runways adjacent to the site.
- During sample collection activities, lead shot and clay pigeon fragments were observed on the ground surface. While not evaluated in this risk assessment, adverse health effects are possible if an individual would ingest the lead shot or clay pigeon fragments.
- In addition to these significant sources of uncertainty, other limitations and uncertainties arise from the quality of the existing toxicological data to support dose-response relationships and the weight of evidence used for determining the carcinogenicity or adverse effects of substances of concern. Uncertainty associated with the exposure assessment includes the values used as input variables for an exposure pathway and the methods used and assumptions made to determine exposure point (or representative) concentrations. Uncertainty in the risk characterization is associated with exposure to multiple hazardous substances and the cumulative uncertainty from combining

conservative assumptions made in earlier steps of the exposure assessment. These uncertainties should be acknowledged in the risk ratio evaluation along with other site and data-specific uncertainties identified during the evaluation of the environmental data collected.

2.7.2 Summary of Ecological Risk Assessment

The ERA was conducted in accordance with several guidance documents (Navy, 1997, 1999; USEPA, 1997, 1998, 2015). This ERA consists of Steps 1, 2, and 3a of the eight step ERA process. The first two screening steps comprise the screening-level ecological risk assessment (SLERA), where conservative exposure estimates are compared to screening-level and threshold toxicity values. Step 3a is the first step of a baseline ERA and consists of refining the conservative assumptions to further focus the ERA process on the chemicals of greatest concern at a site. Steps 3b through 7 consist of additional site-specific investigations/biological studies that are conducted if additional evaluations or investigations are necessary. Aspects of Step 8, risk management, are addressed throughout the ERA process. The compilation of contaminant sources, likely exposure pathways, and receptors at the Skeet Range MRS are depicted in the ecological CSM (Figure 2-8).

2.7.2.1 Identification of Chemicals of Concern

Lead

Lead concentrations in surface soil exceed the USEPA Ecological Soil Screening Level (Eco SSL) for plants of 120 mg/kg in several samples. The following summarizes the number of detections exceeding the screening value and the range of concentrations exceeding the screening value:

- Northern Range Area: 33 of 35 samples (142 to 22,200 mg/kg)
- Southern Range Area: 27 of 76 samples (149 to 1140 mg/kg)
- High Tower Range Area: 4 of 17 samples (129 to 508 mg/kg)

Average lead concentrations in surface soil are greater than the USEPA Eco SSL for plants of 120 mg/kg in the Northern Range Area (1,107 mg/kg) and the Southern Range Area (190 mg/kg) but is less than the plant screening value in the High Tower Range Area (117 mg/kg).

As presented in the SAP (Tetra Tech, 2018), PRGs were developed for plants because the screening level ERA conducted as part of Site Inspection (Tetra Tech, 2009a) concluded that the risks to plants from lead in soil were possible. Although PRGs are generally not used to evaluate risks, for the RI, they were used as risk-based values to re-evaluate potential risks to plants. The PRGs were 240 mg/kg, applied as an average concentration across each decision unit (Northern Range Area and Southern Range Area) and a "not to exceed" value of 750 mg/kg. A few surface soil samples from the Northern Range Area and Southern Range Area have lead concentrations that exceed the "not to exceed" PRG for plants of 750 mg/kg. Only surface soil within the Northern Range Area has an average lead concentration (1,107 mg/kg) that exceeds the plant PRG of 240 mg/kg.

Lead concentrations in subsurface soil are less than surface soil concentrations; however, several samples have concentrations exceeding the plant soil screening value of 120 mg/kg. The following summarizes the number of detections exceeding the screening value and the range of concentrations exceeding the screening value:

- Northern Range Area: 10 of 25 samples (140 to 846 mg/kg)
- Southern Range Area: 10 of 44 samples (121 to 728 mg/kg)
- High Tower Range Area: 4 of 21 samples (124 to 176 mg/kg)

Average lead concentrations in subsurface soil are only slightly greater than the screening value (120 mg/kg) for the Northern Range Area (170 mg/kg) and are less than the screening value for the Southern Range Area (84 mg/kg) and High Tower Range Area (40 mg/kg).

Only one subsurface soil sample from the Northern Range Area has a lead concentration that exceeds the "not to exceed" PRG for plants of 750 mg/kg. Average lead concentrations in subsurface soil are less than the plant PRG of 240 mg/kg.

Based on several soil samples exceeding the plant PRG for lead, lead is retained as a COPC for plants in the Northern Range Area and Southern Range Area. Lead was eliminated as a COPC for plants in the High Tower Range Area since the average lead concentration for surface and subsurface soil was less than the plant PRG of 240 mg/kg.

Lead concentrations in surface soil only exceed the USEPA Eco SSL for soil invertebrate of 1,700 mg/kg in two surface soil samples (2,020 mg/kg and 22,200 mg/kg), both of which were from the southeastern portion of the Northern Range Area. These samples were bounded by samples within approximately 30 feet with lead concentrations less than the invertebrate screening value. All subsurface soil samples have lead concentrations less than the invertebrate screening value. However, because the area will be addressed for other receptors (sediment, invertebrates, and birds), lead will also be retained as a COPC for soil invertebrates in this area.

PAHs

Several PAHs were selected as COPCs because their maximum detected concentrations exceed a LANL plant screening value. The following three PAHs exceed available plant screening values in surface soil samples:

- Acenaphthene: 3 of 51 samples
- Benzo(a)anthracene: 6 of 76 samples
- Benzo(b)fluoranthene: 10 of 76 samples

Several PAHs were selected as COPCs because a screening value was not available to quantitatively evaluate risk to plants from exposure to these PAHs in soil; however, data presented on Table 3.1 in the Eco SSL document for PAHs shows that PAHs are typically not toxic to plants except at high soil concentrations with the lowest listed effective concentration affecting 50 percent of the test organisms (EC50) of 30,000 micrograms per kilogram (µg/kg) from Mitchell et al. (1988). Maximum concentrations of PAHs exceed 30,000 µg/kg in a few samples noted below:

- SR-SS-008: benzo(b)fluoranthene, fluoranthene
- SR-SS-033: fluoranthene
- SR-SS-258: benzo(b)fluoranthene

- SR-SS-257: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, indeno(1,2,3 cd)pyrene
- SR-SS-275: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, indeno(1,2,3-cd)pyrene

These samples are bounded within 35 feet of soil samples with lower concentrations of PAHs. Soil samples SR-SS-008, SR-SS-257, and SR-SS-033 are located within approximately 50 feet of each other. The samples were collected from within the Skeet Range Shooting Area, which consists of mowed grass and an area of deciduous and coniferous scrub. Most of the EC50s and lethal concentrations affecting 50 percent of the test organisms (LC50s) provided in the Eco SSL document (USEPA, 2007) were greater than 1,000,000 µg/kg, with others ranging from 30,000 to 720,000 µg/kg. Although a PAH Eco SSL could not be derived for plants, one of the studies provided in the text of the Eco SSL document (USEPA, 2007) for plants utilized mixed PAHs for the toxicity study. This study provided a lowest observed adverse effect level (LOAEL) of 100,000 µg/kg. No PAH concentrations exceeded this LOAEL. Also, it is not likely that the PAHs are bioavailable because they are bound up in the clay pigeon fragments. Considering that most samples have PAH concentrations less than the lowest available EC50 and the area is heavily vegetated, it is not likely that plants are significantly impacted by PAHs in soil. Therefore, PAHs are eliminated as COPCs for plants.

Several PAHs were selected as COPCs because their maximum detected concentrations exceed the Eco SSL for soil invertebrates. Except for fluoranthene, all of the PAHs initially selected as COPCs for invertebrates are high molecular weight PAHs. The following PAHs exceed the soil invertebrate screening value at the following frequencies (not counting duplicates):

- Benzo(a)anthracene: 6 of 76 samples
- Benzo(a)pyrene: 5 of 76 samples
- Benzo(b)fluoranthene: 9 of 76 samples
- Benzo(g,h,i)perylene: 1 of 51 samples
- Benzo(k)fluoranthene: 2 of 76 samples
- Chrysene: 5 of 76 samples
- Fluoranthene: 2 of 51 samples
- Indeno(1,2,3-cd)pyrene: 4 of 76 samples
- Pyrene: 3 of 51 samples

A PRG was not developed for PAHs. Overall impacts to invertebrates are not expected to be significant because there are only 9 locations where PAH concentrations are greater than the invertebrate screening value, and it is not likely that the PAHs will be bioavailable because they are bound up in the clay pigeon fragments. Therefore, PAHs are eliminated as COPCs for soil invertebrates.

2.7.2.2 Exposure Assessment

Sediment Invertebrates

The wetland boundary within the Northern Range Area is marginal and shifts depending on rainfall and water coming through the drainage area; therefore, habitat for sediment invertebrates may not be present at all low-lying areas sampled. Terrestrial receptors are more likely than aquatic receptors to inhabit the wetland portion of the site during much of the year. However, because the sediment may eventually move downstream and impact Little Mosquito Creek, or the tidal marsh adjacent to the creek, surface soil samples in the low-lying area within the Northern Range Area were also evaluated for risks to sediment invertebrates. All lead concentrations (104 to 22,220 mg/kg) exceed the sediment screening value of 30.2 mg/kg. The screening value of 30.2 mg/kg is a USEPA Region 3 marine sediment screening benchmark (USEPA, 2006) and is based on the threshold effect level (TEL), which is the concentration at which adverse effects are not expected. The source document for the TEL screening value also provides a benchmark for a higher effect level, which is the probable effect level (PEL). The PEL is the concentration at which adverse effects are likely. Lead concentrations in 26 of 28 locations exceed the PEL of 112 mg/kg (MacDonald, 1996). While erosion of sediment/soil from the site into the tidal marsh and Little Mosquito Creek is limited because the area is heavily vegetated, lead is retained as a COPC for sediment invertebrates.

As presented in the SAP (Tetra Tech, 2018), a PRG of 530 mg/kg lead was recommended for this area, which is the Washington State sediment cleanup level. The basis for this value is that use of a PRG at the site of 530 mg/kg lead will result in much lower lead concentrations for sediment invertebrates at the exposure point for sediment invertebrates (Little Mosquito Creek). Although PRGs are generally not used to evaluate risks, for the RI, they were used as risk-based values to evaluate potential risks to sediment invertebrates. The PRG was to be applied as a “not to exceed” concentration for those samples. Thirteen of 28 locations have lead concentrations exceeding the PRG. Lead concentrations are greater than the PRG developed as part of the SAP; therefore, lead is retained as a COPC for sediment invertebrates.

Dibenzo(a,h)anthracene was initially selected as a COPC in sediment because the detected concentration (SR-SS-038-000.5 at 9.4 µg/kg) exceeds it screening value. However, the toxicity of PAHs is typically assumed to be additive, so evaluating PAH toxicity in sediment by examining total PAH concentrations is especially useful when several PAHs are detected. Concentrations of total PAHs in sediment are less than the screening level for total PAHs of 2,900 µg/kg. Therefore, risks to sediment invertebrates from PAHs are not expected.

Mammals and Birds

The EEQs from the terrestrial food chain modeling for soil were greater than 1.0 for several chemicals using maximum chemical concentrations and conservative exposure assumptions. Therefore, as part of the Step 3a refinement, risks for this pathway were recalculated using average chemical concentrations in surface soil and less conservative exposure assumptions (i.e., average ingestion rates, average body weights) (see Appendix I of the RI).

A discussion of the risks to mammal and birds exposed to soil is presented below. Only lead concentrations within soil are evaluated as part of the food chain modeling summarized below. Risks to birds from exposure to lead shot are discussed separately.

- Herbivorous receptors: All EEQs for the vole were less than 1.0 using the no observed adverse effect level (NOAEL) as the toxicity reference value (TRV). The NOAEL EEQ for lead was greater than 1.0 for the quail for surface soil from the Northern Range Area (3.9). All LOAEL EEQs were less than 1.0 for the quail. Therefore, lead and PAHs in soil are not retained as COPCs for risks to herbivorous birds and mammals.
- Insectivorous receptors: The EEQs for the shrew for surface soil were greater than 1.0 using the NOAEL as the TRV for lead (4.5) from the Northern Range Area; and lead (1.1), benzo(b)fluoranthene (2.1), chrysene (1.5), and indeno(1,2,3-cd)pyrene (1.4) from the Southern Range Area/Skeet Range Shooting Area. The NOAEL EEQs for the robin were greater than 1.0 in surface soil for lead (27) from the Northern Range Area, lead (6.1) and benzo(b)fluoranthene (1.1) from the Southern Range Area/Skeet Range Shooting Area, and lead (4.1) from the High Tower Range Area; and subsurface soil for lead from the Northern Range Area (5.6), the Southern Range Area (3.1), and the High Tower Range Area (1.7). Except for lead from the Northern Range Area, NOAEL EEQs were only slightly greater than 1.0. LOAEL EEQs were less than or equal to 1.0 for the shrew and robin. Therefore, lead and PAHs in soil are not retained as COPCs for risks to insectivorous mammals; however, as discussed below, lead is retained as a COC for insectivorous birds.

As presented in the SAP (Tetra Tech, 2018), PRGs were developed for birds because the screening level ERA conducted as part of Site Inspection (Tetra Tech, 2009a) concluded that the risks to birds from lead in soil were possible. Although PRGs are generally not used to evaluate risks, for the RI, they were used as risk-based values to re-evaluate potential risks to birds. The PRGs developed in the SAP (Tetra Tech, 2018) for insectivorous birds exposed to lead concentrations in soil include a “not to exceed” value of 1,100 mg/kg and an average concentration across the site of 299 mg/kg. Several locations in the Northern Range Area exceed the “not to exceed” value of 1,100 mg/kg. The average concentration in surface soil (1,107 mg/kg) from the Northern Range Area was greater than the PRG of 299 mg/kg. Average concentrations were less than the PRG of 299 mg/kg for subsurface soil from the Northern Range Area and surface and subsurface soil from the Southern Range Area and High Tower Range Area. Therefore, even though the LOAEL EEQs were less than 1.0 using average soil concentrations, lead concentrations are greater than the PRG developed as part of the SAP in the Northern Range Area. Therefore, lead is retained as a COPC for insectivorous birds in this area.

2.7.2.3 Ecological Effects Assessment

The following factors were evaluated, as appropriate, to determine if the risks are great enough to warrant additional evaluations.

- Magnitude of Criterion Exceedance: Although the magnitude of the risks may not relate directly to the magnitude of a criterion exceedance, the magnitude of the criterion exceedance may be one item used in a lines-of-evidence approach to determine the need for further site evaluation. The greater the criterion exceedance, the greater the probability and concern that an unacceptable risk exists.
- Frequency of Screening Level Exceedance and Spatial Distribution: A chemical detected at a low frequency at concentrations that exceed a screening level are typically of less concern than a chemical with a higher frequency of exceedances assuming spatial areas represented by the data are similar. All else being equal, chemicals detected more frequently at concentrations greater that

their respective screening levels were given greater consideration than those with fewer exceedances.

- Contaminant Bioavailability: Many contaminants (especially inorganics) are present in the environment in forms that are typically not bioavailable, and the limited bioavailability was considered when evaluating the exposures of receptors to site contaminants. Contaminants with generally less bioavailability are considered to be less toxic than the more bioavailable contaminants, all other factors being equal.
- Additional Toxicity Data: Additional toxicity data were used to further evaluate risks to specific groups of ecological receptors (e.g., plants, invertebrates, and benthic organisms) because while conservative screening levels are useful for initial screening, they may not be available or appropriate for all of the assessment endpoints.
- Food Chain Modeling: Exposure via the food chain is a major pathway of concern for chemicals known to significantly bioaccumulate and/or biomagnify. Thus, potential risk to upper level receptors was evaluated using food chain models. The conservative exposure doses calculated for terrestrial wildlife were re-calculated using the following less conservative exposure assumptions and chemical concentrations:
  - Average chemical concentrations in media
  - Average receptor body weights and ingestion rates

2.7.2.4 Ecological Risk Characterization

No Federal or State values have been promulgated for allowable levels of lead shot in soil. Therefore, as presented in the SAP (Tetra Tech, 2018), a probability model presented in an USEPA document titled, Assessment of Methods for Estimating Risk to Birds from Ingestion of Contaminated Grit Particles (Bennett, 2011) was used to evaluate risks to birds from ingesting lead shot. The model uses the number of lead shot and non-lead particles (i.e., sand, gravel, rocks) to calculate the probability for birds to ingest a lead particle from the site using site-specific parameters. The USEPA model includes a spreadsheet that can be used to calculate the probability for birds to ingest a lead particle from the site using site-specific parameters. Several of the site-specific values used in the model came from the Ecological Risk Assessment for Range 17 (Trap and Skeet Range), Patuxent Research Refuge (USFWS and USEPA, March 2004). The area use factor (the F parameter) is assumed to be 0.5 percent or 0.005. This was calculated by dividing the approximate size of the area where lead shot was identified at the Skeet Range (approximately 2.5 acres) by the home range of mourning doves (538 acres) from USFWS and USEPA, (March 2004).

Soil was passed through a series of sieves to determine the number of lead shot and non-lead particles within various size ranges. All soil samples that were sieved were passed through a No.10 sieve (2 mm), while select samples were passed through a No. 14 sieve (1.4 mm), No. 20 sieve (0.84 mm), and No. 35 sieve (0.5 mm). Most of the lead shot were found on the No. 10 sieve, with a few lead shot found on the No. 14 sieve; no lead shot were found on the No. 20 or No. 35 sieves.

As presented in (Bennett, 2011), the mean particle size found in the gizzard of mourning doves was 2.1 mm. Because some of the non-lead particles retained on the No. 10 sieve were much greater than 2 mm, for this modeling, only the non-lead particles that passed through the No. 10 sieve and were retained on the No. 14 sieve (between 1.41 and 2 mm) and retained on the No. 20 sieve (between 1.41 and 0.84 mm)

were used for the modeling. All of the lead shot were included in the modeling. Although the non-lead particles retained on the No. 14 sieve likely represents the lower range of grit consumed by mourning doves, the modeling was conducted for non-lead particles retained on the No. 20 sieve for informational purposes.

The probability models are included in Appendix I of the RI. The probability modeling was conducted for all three depth intervals (0 to 6 inches, 6 to 12 inches, and 12 to 24 inches), although the primary exposure to birds would be to lead shot in the top six inches. Generally higher numbers of lead shot were found in the 0 to 6-inch interval.

As discussed in more detail in the SAP (Tetra Tech, 2018), because the habitat at the Skeet Range MRS is not a wildlife refuge or other type of potentially sensitive environment, a probability of 20 percent that a bird would ingest one lead shot was the basis of the lead shot PRG. Therefore, this same probability level is used to determine unacceptable risks to birds in this risk assessment. With one exception of 94 lead shot/ft^2 in sample SR-SS-407-0006, the probability of ingesting lead shot was less than 20 percent when 100 or fewer lead shot were present in a sample (based on non-lead particles retained on the No. 14 sieve). When based on non-lead particles retained on the No. 20 sieve, the probability of ingesting lead shot was less than 3 percent.

Although the majority of samples were only sieved through a No. 10 sieve (only about 30 percent of the samples were also sieved through a No. 14 sieve), it is assumed that the proportion of lead shot/non-lead grit-sized particles would be the same in all samples. Approximately 35 percent of the samples have greater than 100 lead shot/ft^2, and with a few exceptions, most of these were from samples collected in the 0-to-6-inch depth interval. This indicates that even though birds feed over a larger area than represented by a single sample point, there are potential impacts to birds from ingestion of lead shot because of the relatively large number of locations where the number of lead shot particles exceed 100 lead shot/ft^2.

The recommended not-to-exceed ecological PRGs for lead in the Northern Range Area is 530 mg/kg (protective of sediment invertebrates) and 750 mg/kg for the Southern Range Area/Skeet Range Shooting Area and High Tower Range Area.

2.7.3 Ecological Risk Assessment Conclusion

Historical skeet shooting activities conducted at the Skeet Range MRS resulted in the presence of lead and PAH contamination in surface and subsurface soil from lead shot and clay pigeon fragments. This ERA evaluated surface and subsurface soil data across the Skeet Range MRS. Low-lying soils were also evaluated as sediment samples. Based on the initial screening of the chemical data, lead and several PAHs were initially selected as COPCs because they were detected at concentrations that exceeded conservative screening levels, they had EEQs greater than 1.0 in the conservative food chain model, or because they did not have screening levels.

Lead and PAHs were then further evaluated to refine the list of COPCs, and to better characterize risks to ecological receptors. As discussed in the Exposure Assessment earlier, PAHs were eliminated as COPCs for all ecological receptors in all areas for soil/sediment and plants. Lead was retained as a COPC for risks to the following receptors in the following areas:

- Terrestrial plants in the Northern and Southern Range Areas (it was eliminated as a COPC for plants in the High Tower Range Area).

- Soil invertebrates in the southeastern portion of the Northern Range Area.
- Sediment invertebrates in the low-lying portion of the Northern Range Area.
- Insectivorous birds in the Northern Range Area.
- Birds in areas with greater than 100 lead shot/ft^2.

The response action selected in this ROD is necessary to protect public health, welfare, and the environment from releases of contaminants from this site which may present imminent and substantial endangerment.

2.8 REMEDIAL ACTION OBJECTIVES

Based on the exposure pathways and receptors present at the Skeet Range MRS and the ecological COPCs, the below remedial action objectives (RAOs) were developed:

- Reduce potential risks exceeding USEPA risk thresholds due to the residential and industrial exposure to lead and PAHs in surface and subsurface soil above the cleanup levels.
- Reduce potential risks to ecological receptors from exposure to lead in surface and subsurface soil and sediment above the cleanup levels.
- Reduce potential risks to ecological receptors from exposure to lead shot in surface and subsurface soil above the cleanup level.
- Reduce migration of lead from upland soil to sediment in Little Mosquito Creek at levels that cause potential risk to the environment.

The Skeet Range MRS COCs and associated cleanup levels for the RAOs are presented below. In developing the cleanup levels, the same methodology used to calculate the ecological and human risks were used to calculate the concentrations that would result in no adverse effects to the receptors. The calculated concentration was compared to the available background threshold value and the higher of the two was selected as the cleanup level. Based on the background threshold values calculated and approved in 2021, all cleanup levels are based on risk-based levels. The cleanup levels for the Skeet Range MRS are based on protection of the ecological and human receptors and meet residential use standards.

Receptors (COC)	Cleanup Max	Cleanup Average
Plants (Lead)	750 mg/kg	240 mg/kg
Birds (Lead)	1,100 mg/kg	299 mg/kg
Birds (Lead shot)	100 LS/ft^2	Not Applicable (NA)
Sediment Invertebrates (Lead)	530 mg/kg	NA
Human Health (Lead)	NA	200 mg/kg
Human Health (target PAHs)	1x10^{-4} ILCR	NA

2.9 DESCRIPTION OF ALTERNATIVES

Remedial alternatives evaluated for the Skeet Range MRS are presented below. More detailed descriptions of the alternatives can be found in the Feasibility Study Report (Tetra Tech, 2021).

2.9.1 Description of Remedy Components

This section provides a list of the major components of each alternative as they occur in the remediation process. Each list includes treatment components and the materials they will address, institutional controls, O&M activities to maintain the integrity of the remedy, and monitoring requirements. In addition, the applicable or relevant and appropriate requirements (ARARs) are listed and summarized in Table 2-7 of this ROD.

The three remedial alternatives for the Skeet Range MRS are described in the following subsections:

- Alternative No. 1 - No Action
- Alternative No. 2 - Excavation and Off-Site Disposal
- Alternative No. 3 - Excavation, On-Site Consolidation, Soil Cover, O&M, And LUCs

2.9.1.1 Alternative 1 - No Action

CERCLA requires evaluation of a No Action alternative. Under Alternative 1, no further efforts or resources will be expended at the Skeet Range MRS. No action will be implemented to address the existing contamination at the Skeet Range MRS. Alternative 1 serves as the baseline for comparing the other alternatives.

2.9.1.2 Alternative 2 – Excavation and Off-Site Disposal

Alternative 2 includes the following components:

- Sampling of soil/sediment for off-site disposal requirements,
- Stabilization of soil/sediment prior to excavation as needed to convert it into non-hazardous waste,
- Excavation of approximately 5,890 cubic yards (CY)/ 8,830 tons of contaminated soil/sediment,
- Off-site disposal of excavated soil/sediment,
- Post-excavation confirmation soil/sediment sampling,
- Backfill of the excavated areas with 5,900 CY of clean fill material, and
- Ground surface restoration.

In Alternative 2, the contaminated soil/sediment with COC concentrations above the Cleanup Goals from 0-to-1-foot depth interval will be excavated from the Skeet Range MRS.

Before site activities begin, a desktop-like cultural resources evaluation will take place. NASA will coordinate with the Virginia Department of Historic Resources and appropriate Native American tribes and will notify them if any artifacts and/or human remains are encountered.

Prior to excavation activities, the soil/sediment will be sampled for analytical requirements required for disposal at an off-site facility. The soil/sediment analytical data collected will be submitted to the appropriate disposal facilities for ultimate approval prior to implementation of any alternative that includes off-site disposal. If it is determined that a portion of the soil is characteristically hazardous for lead, that portion of the soil will be chemically stabilized via mixing with a reagent to bind the leachable lead to the soil and

render it non-hazardous. It is anticipated that non-hazardous excavated soil/sediment will be loaded directly into dump trucks with no need of on-site management. It is anticipated that excavated soil/sediment from the site will be transported to a Resource Conservation and Recovery Act (RCRA) Subtitle D landfill for disposal as non-hazardous waste.

Depending upon site conditions at the time of the remedial action, dust controls may be necessary during excavation activities to reduce the potential exposure through inhalation of particulates. Prior to excavation activities, erosion controls (e.g., silt fence) will be installed around the excavation area to prevent the contaminated soil/sediment from migrating beyond construction areas via surface erosion and runoff. Prior to site restoration activities, post-excavation confirmation soil/sediment sampling for COCs will be conducted in the excavated areas to document compliance with the Cleanup Goals.

Restoration of all ground surface, habitats, coastal areas, and wetlands disturbed by Alternative 2 activities will be performed. Any impacted palustrine forested wetland habitat or other jurisdictional wetlands will be restored per wetland mitigation requirements. The specific mitigation measures will be detailed in the project planning and design documents.

Alternative 2 eliminates the need for land use controls (LUCs) and Five-year review (FYRs), because concentrations of contaminants would be acceptable for unlimited use and unrestricted exposure at the site.

2.9.1.3 Alternative 3 - Excavation, On-Site Consolidation, Soil Cover, O&M, And LUCs

Alternative 3 includes the following components:

- Sampling of soil/sediment for off-site disposal requirements,
- Stabilization of soil/sediment prior to excavation as needed to convert it into non-hazardous waste,
- Excavation of 2,830 CY of soils/sediment from several areas,
- Consolidating the soils/sediment on top of other contaminated soil in a portion of the Southern Range Exposure Area in a 1-foot-thick layer,
- Covering the consolidated contaminated materials and remaining in situ contamination with protective layers of soil as a barrier using 7,210 CY of clean fill materials, and
- Performing O&M and implementing and maintaining LUCs to achieve the RAOs. Certain areas will be excavated, backfilled, and restored, while others will remain in place or be covered.

In Alternative 3, the soil from the areas containing contamination above cleanup levels will be covered with a clay cap consisting of a geotextile liner (to prevent erosion and burrowing) and approximately 2 feet of clean clay. LUCs (listed below) will also be implemented to control or manage any intrusive activities that will penetrate the soil cap. Depending upon the Skeet Range MRS conditions at the time of the remedial action, dust controls might be necessary during cap construction to reduce potential exposure to workers through inhalation of contaminated particulates. Erosion controls (i.e., silt fence) will be installed as a vertical barrier around the work area to prevent the potential migration of contaminated soil off-site via runoff. A vegetative ground cover and geotextile liner will be established on top of the soil cover for erosion

control purposes. Five-year reviews will be required to demonstrate that the remedy remains protective of human health and the environment.

COCs will remain on-site. Therefore, the following LUCs will be implemented as part of Alternative 3:

- Signs to prohibit soil disturbance and protect cap integrity,
- Master Plan revisions to document access restrictions and maintenance of LUCs, and
- FYRs to assess whether soil cover and controls in place are meeting RAOs.

Restoration of all ground surface, habitats, coastal areas, and wetlands disturbed by Alternative 3 activities will be performed. Any impacted palustrine forested wetland habitat or other jurisdictional wetlands will be restored per wetland mitigation requirements. The specific mitigation measures will be detailed in the project planning and design documents.

Preparation of the five-year review report would be required for Alternative 3 to evaluate the effectiveness of the cap and LUCs at achieving the RAO.

2.9.2 Common Elements and Distinguishing Features of Each Alternative

Alternative 2 does not include LUCs or FYRs, while Alternative 3 would require LUCs in addition to a low-permeability cap to reduce the ecological and human risk. Because contaminants would remain on-site, Alternative 3 would require five-year reviews to assess the adequacy of the remedial activities, and to determine whether further action is necessary.

The present worth costs of Alternatives 2 and 3 are assessed based on capital costs (initial cost to implement) and annual O&M costs. The estimated present worth costs are as follows:

- Alternative 1: $0
- Alternative 2: $2,386,000
- Alternative 3: $2,215,000

2.9.3 Expected Outcome of Each Alternative

For Alternative 1, no actions would be implemented, thereby resulting in unacceptable risks to the environment from exposure to contaminated soil and sediment. For Alternative 2, risk to human and ecological receptors would be eliminated and the site would allow for unrestricted future use. For Alternative 3, potential risk to ecological and human receptors would be controlled. LUCs would be in place to restrict soil and sediment exposure to potential future industrial workers and residents. Site activities would be controlled through restrictions documented in the Facility Master Plan. The LUCs would be required for an extended period of time and FYRs would be required to assess adequacy.

2.10 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The objective of the comparative analysis of alternatives is to evaluate the relative performance of the alternatives with respect to the nine evaluation criteria established in the NCP so that the advantages and disadvantages of each are clearly understood. The first two evaluation criteria, Overall Protection of Human

Health and the Environment and Compliance with ARARs, are threshold criteria that must be satisfied by a remedial alternative chosen for a site. Table 2-8 contains a summary of the comparative analysis of alternatives.

2.10.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

Alternatives 2 and 3 are protective of human health and the environment because they will provide some level of protection to ecological and human receptors from short-term and long-term risks associated with the Skeet Range MRS contaminated soil and sediment. Alternative 2 will be protective by fully removing the source of the contamination. Alternative 3 will be protective by controlling environmental receptors from accessing and restricting human exposure to the Skeet Range MRS contaminated soil. COCs will remain on-site. Alternative 3 will not reduce vertical contaminant migration via infiltration processes and, therefore, will be less protective of the environment than Alternatives 2. Alternative 3 will reduce the potential for ecological receptors to access the soil and sediment, provided the integrity of the cap is maintained, and will restrict human receptor access. COCs will remain on-site. Migration of COCs will be controlled by the installation of the cap and geotextile liner. Alternative 1 will not protect human health or the environment because no reduction in soil and sediment contaminant concentrations and no reduction in ecological or human receptor exposures will occur.

2.10.2 Compliance with ARARs

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes or provides a basis for a invoking waiver.

No chemical-specific ARARs were identified for the Skeet Range MRS. Alternative 2 will remove soil and sediment above the PRGs. Ecological and human receptors will not be in contact with soil having COC concentrations greater than the PRGs because the soil will be removed from the Skeet Range MRS. Alternatives 2 and 3 will comply with both location-specific and action-specific ARARs. Under Alternative 3, COCs will remain on-site above PRGs. Alternative 1 would not comply with any ARARs because there are no remedial actions associated with this alternative.

2.10.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.

Alternative 2 will provide the greatest long-term effectiveness because potential risks to ecological and human receptors will be eliminated by the removal of soil and sediment and COCs above cleanup levels. Alternative 3 is less effective than Alternative 2 because COCs above PRGs will remain on-site, and the effectiveness of Alternative 3 is a function of maintaining the integrity of the low-permeability cap and

institutional controls. Alternative 1 has the lowest long-term effectiveness and permanence because no action is taken. Only Alternative 2 will provide unrestricted land use because the contaminated soil and sediment above the cleanup levels will be removed from the Skeet Range MRS.

2.10.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

None of the alternatives provide treatment. Therefore, none of the alternatives satisfy the preference for treatment as a principal element.

2.10.5 Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community and the environment during construction and operation of the remedy until cleanup levels are achieved.

Alternative 1 is most effective in the short term because there will be no activities that would expose the community or workers to site contaminants. Alternatives 2 and 3 provide comparable short-term effectiveness. They both pose potential short-term safety risks to site workers due to earthwork construction activities. Alternative 2 includes 400 truckloads of excavated soils for off-site disposal. Both alternatives involve the import and placement of clean soil materials: Alternative 2 would require 400 truckloads of clean soil materials for backfilling/restoration and Alternative 3 would require approximately 690 truckloads for backfilling/restoration and the soil cover. Short-term risks to site workers would be mitigated using personal protective equipment, conventional dust suppression techniques, and site health and safety monitoring for both alternatives.

2.10.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

Alternative 1 is the easiest to implement because it requires no action. Both Alternatives 2 and 3 would require coordination with several agencies, including with NOAA and the airfield operations prior to and during construction. Both alternatives require erosion and sedimentation controls due to disturbing greater than 1 acre of land.

Alternative 2 is relatively easy to implement and involves standard construction techniques and equipment. There are ample companies with the trained personnel, equipment, and materials to perform site preparation and conduct soil excavation. There are several off-site landfills located within a reasonable distance from NASA WFF that accept non-hazardous CERCLA waste. Experienced and trained workers and contracting companies are capable and readily available to stabilize, excavate, and transport the lead, lead shot-, and PAH-contaminated soils to the appropriate disposal facility. Alternative 2 could include chemical stabilization of hazardous lead-contaminated soils prior to off-site transportation and disposal, but this technology has been widely tested and implemented at various remediation sites. The chemical

stabilization reagents are typically proprietary, but do not necessarily need to be applied by specialty subcontractors.

Alternative 3 is also relatively easy to implement using the same standard companies, construction techniques, and equipment as Alternative 2. Alternative 3 does not include off-site disposal of the excavated soil and sediment, but it does include the same assumed lead stabilization treatment to render any hazardous materials to be non-hazardous. It requires half the excavation as Alternative 2 but almost double the imported backfill and topsoil due to the 2-foot soil cover. The long-term mission of NASA's airfield and NOAA's antennae facility could be affected by the 2-acre soil cover (e.g., if future expansion of the facility or airfield is needed). Also, long-term tasks (LUCs and O&M of soil cover) are required for Alternative 3 to maintain protectiveness. LUCs, LUC inspections, and reporting are easily implementable.

2.10.7 Cost

Alternative 1 involves no action; therefore, no cost is associated with this alternative. The estimated capital cost of the excavation, consolidation, and construction of a soil cover under Alternative 3 is $1,568,000. The future O&M and monitoring (LUC inspections and cover maintenance) costs of Alternative 3 would be $11,000 each of the first 2 years and then $3,100 annually thereafter; soil cover maintenance every 5 years would be $8,000; and Five-Year Reviews would be $15,000 every 5 years. Considering the future costs, the net present worth (NPW) of the total cost for Alternative 3 over a 30 and 100-year period is estimated to be $1,801,000 and $2,216,000 respectively. Alternative 2 costs the most with a NPW of approximately $2,386,000.

2.10.8 State Acceptance

The Commonwealth of Virginia has expressed its support of Alternative 2 and agrees with the Selected Remedy described in Section 2.12 below.

2.10.9 Community Acceptance

Because no comments were expressed at the public information session, and only one comment was received by email during the public comment period, it appears that the community generally agrees with the Selected Remedy. Specific details regarding the public comment period can be found in the Responsiveness Summary section of this ROD.

2.11 PRINCIPAL THREAT WASTES

The NCP establishes an expectation that treatment will be used to address the principal threats posed by a site wherever practicable [40 CFR 300.430(a)(1)(iii)(A)]. Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. Based on the results of the investigations, studies, and sampling conducted, the contaminated soil and sediment at the Skeet Range MRS does not constitute a principal threat waste as defined by the NCP. The contaminated Skeet Range MRS soil and sediment is considered to be of low toxicity and concentrations; therefore, would not be categorized as a principal threat waste.

2.12 SELECTED REMEDY

2.12.1 Summary of Rationale for the Selected Remedy

Alternative 1 does not meet the threshold criteria and COCs above cleanup levels will remain on-site. Alternative 3 is more protective of ecological receptors than Alternative 1, but COCs above cleanup levels will also remain on-site under Alternative 3. Alternative 2 is the most protective of ecological and human receptors because contaminated soil and sediment with COCs above cleanup levels will be removed. Therefore, Alternative 2 will provide a permanent solution that will remain effective over time. Alternative 3 requires ongoing maintenance of engineered and institutional controls to remain effective and will require more extensive maintenance. Alternative 3 involves the greatest degree of short-term physical hazards to on-site workers and the community due to the amount of truck traffic associated with transporting capping materials to the Skeet Range MRS. A lesser degree of short-term physical hazards to on-site workers and the community would be posed by Alternative 2 due to the lesser volume of materials requiring transport. Of the two alternatives (Alternatives 2 and 3) that reduce potential human health and ecological risks to acceptable levels upon implementation, Alternative 2 is the most cost-effective because it provides a greater level of protection to potential ecological receptors and providing for unrestricted land use and unlimited exposure.

2.12.2 Description of Selected Remedy

The Selected Remedy is Alternative 2 – Soil and Sediment Removal and Off-Site Disposal. The Selected Remedy was formulated and analyzed to evaluate a remedial action that removes all known and potential risks to ecological and human receptors under the future hypothetical residential scenario. As discussed earlier in Section 2.9.1.2, Alternative 2 includes the following components:

- Sampling of soil/sediment for off-site disposal requirements,
- Stabilization of soil/sediment prior to excavation as needed to convert it into non-hazardous waste,
- Excavation of approximately 5,890 cubic yards (CY)/ 8,830 tons of contaminated soil/sediment,
- Off-site disposal of excavated soil/sediment,
- Post-excavation confirmation soil/sediment sampling,
- Backfill of the excavated areas with 5,900 CY of clean fill material, and
- Ground surface restoration.

Before site activities begin, a desktop-like cultural resources evaluation will take place. NASA will coordinate with the Virginia Department of Historic Resources and appropriate Native American tribes and will notify them if any artifacts and/or human remains are encountered.

Site preparation includes mobilization and setup of support facilities, utility clearance surveys, vegetation removal, temporary road construction, and establishment of soil E&S controls. Equipment and support facilities (e.g., excavators, loaders, office trailer, storage containers, sanitary facilities, etc.) will be mobilized to the site and set up or staged at approved locations. Utility clearance surveys, vegetation removal, and temporary road construction will be conducted where necessary to expose or provide access to the areas marked for excavation. Depending upon site conditions at the time of the remedial action, dust controls may

be necessary during excavation activities to reduce the potential exposure through inhalation of particulates. E&S control measures (e.g., silt fence and straw bales) will be established to ensure that soil disturbance activities do not adversely impact downgradient surface water bodies, floodplains, tidal marshes, or wetlands. During vegetation clearance, temporary road construction, soil excavation and stockpiling, waste loading, backfilling, and regrading operations, E&S controls will be regularly inspected and maintained until excavation and backfilling is complete and the site vegetation is re-established. An E&S Control Plan would be prepared as part of the work plan, in accordance with the substantive stormwater runoff protection requirements of VDEQ and the State Water Control Board.

Excavation operations would be performed by qualified excavation personnel with current HAZWOPER training, as required by OSHA. Standard dust control techniques would be used during removal activities to mitigate fugitive dust emissions. Excavation areas would be cordoned off during the excavation to prevent any trespassers from being exposed to contamination until the contaminated soil is removed.

All lead-, lead shot-, and PAH-contaminated soils and sediments with COC concentrations greater than their respective Cleanup Goals would be excavated, characterized, and direct-loaded or containerized for transportation and off-site disposal. This alternative would include the removal of approximately 5,884 cubic yards of contaminated soil and sediment over an area of approximately 3.65 acres to a depth of 1 foot. These areas are shown in Figure 2-9. The excavation limits would be defined by soil and sediment with COC concentrations that exceed cleanup levels. The alternative would also include the collection of verification samples to confirm the removal of soil contamination causing unacceptable ecological and human health risk. In addition, all construction/excavation-derived material and investigation-derived waste would be characterized prior to disposal. Prior to excavation activities, the soil/sediment will be sampled for analytical requirements required for disposal at an off-site facility. The soil/sediment analytical data collected will be submitted to the appropriate disposal facilities for ultimate approval prior to loading the soil/sediment for off-site disposal. If it is determined that a portion of the soil is characteristically hazardous for lead, that portion of the soil will be chemically stabilized via mixing with a reagent to bind the leachable lead to the soil and render it non-hazardous. It is anticipated that non-hazardous excavated soil/sediment will be loaded directly into dump trucks with no need of on-site management. Excavated soil and sediment from the Skeet Range MRS will be transported to a RCRA Subtitle D landfill for disposal as non-hazardous waste. Prior to Skeet Range MRS Site restoration activities, post-excavation confirmation sampling for COCs will be conducted in the excavated areas to document compliance with the cleanup levels and to document unlimited land use and unrestricted exposure.

Prior to site restoration activities, post-excavation confirmation soil/sediment sampling for COCs will be conducted in the excavated areas to document compliance with the Cleanup Goals. NASA may elect to collect sufficient pre-excavation soil/sediment samples to delineate the extent of excavation, thereby, eliminating the need for post-excavation sampling. Restoration of all ground surface, habitats, coastal areas, and wetlands disturbed by Alternative 2 activities will be performed. Any soil/sediment disturbed from the palustrine forested wetland habitat will follow wetland mitigation activities and will be backfilled with loamy fill. This will allow for a natural revegetation resulting in no net loss of habitat.

Alternative 2 eliminates the need for land use controls (LUCs) and Five-year review (FYRs), because concentrations of contaminants would be acceptable for unlimited use and unrestricted exposure at the site.

2.12.3 Summary of Estimated Remedy Costs

Cost estimate summaries for the Selected Remedy are provided in Table 2-8 (capital cost) and discussed earlier in Section 2.10.7. The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. The estimated present worth of the Selected Remedy is $2,386,000. Changes in the cost elements may occur because of new information or data collected during the engineering design of the Selected Remedy. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Differences (ESD), or a ROD amendment depending on the scope of the change. This is an order-of-magnitude engineering cost estimate that is expected to be within plus 50 to minus 30 percent of the actual project cost. These estimates are refined as the remedy is designed and implemented.

2.12.4 Expected Outcomes of the Selected Remedy

After the Selected Remedy has been implemented, COCs exceeding cleanup levels in soil and sediment would be removed from the site. There would be unrestricted use for site soil and no LUCs. The estimated time to achieve the RAO is two months of onsite work.

2.12.5 Performance Standards

Maximum and average cleanup values for various receptors are included in Section 2.8; these will be the performance standards for the remedy.

A Remedial Design and Remedial Action Work Plan and Reports will be prepared for USEPA and VDEQ review and USEPA approval. These documents will detail the excavation, sampling and analysis, data assessment, backfill, regrading, revegetation, and site restoration requirements to be implemented as part of the Selected Remedy.

2.13 STATUTORY DETERMINATIONS

Under CERCLA Section 121 and the 40 CFR 300.430(f)(5)(ii) of the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost effective, and utilize permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the toxicity, mobility, or volume of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the Selected Remedy meets these statutory requirements.

2.13.1 Protection of Human Health and the Environment

The Selected Remedy, Alternative 2, will protect human health and the environment by removing soil and sediment containing COCs above cleanup levels and properly disposing of such. Unrestricted use requirements will be met under Alternative 2.

There are no short-term threats associated with the Selected Remedy that cannot be readily controlled. In addition, proper controls such as dust controls or silt fencing will be used to control cross-media impacts during implementation of the Selected Remedy.

2.13.2 Compliance with ARARs

Chemical-specific ARARs

Although no chemical-specific ARAR was identified for the contaminated soil and sediment, Alternative 2 will comply with the cleanup levels for the soil and sediment COCs because soil and sediment with concentrations greater than the cleanup levels will be removed from the Skeet Range MRS.

Location-specific ARARs

Location-specific ARARs and TBCs applicable to Alternative 2 include protection of coastal resources, endangered species, wetland habitats, floodplain management, and archaeological preservation. Some of these acts include the Coastal Zone Management Act, Archaeological and Historic Preservation Act, Endangered Species Act, Fish and Wildlife Coordination Act, and the Protection of Wetlands and Floodplain Management Executive Orders. During remedial activities, efforts will be made to comply with all applicable ARARs and TBCs including appropriate erosion, sediment control, and spill prevention measures, native wetland preservation and reseeding, and attention to any and all endangered species and archaeological discoveries.

Action-specific ARARs

Action-specific ARARs applicable to Alternative 2 include possible impacts to air quality during any grading and removal operations. During the construction, reasonable precautions will be employed to prevent particulate matter from becoming airborne. Fugitive dust will be limited through effective Skeet Range MRS watering during any grading or removal operations. Compliance with RCRA and Virginia Solid Waste Management Regulations during off-site transport and disposal of contaminated soil and sediment will be ensured through the use of a United States Department of Transportation licensed transporter for hauling of materials and off-site disposal at a VDEQ-approved facility for disposal of RCRA Subtitle D waste (non-hazardous solid waste).

2.13.3 Cost-Effectiveness

The Selected Remedy is cost effective. In making this determination, the following definition was used [40 CFR 300.430(f)(1)(ii)(D)]: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness." NASA first evaluated the "overall effectiveness" of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment and in compliance with ARARs). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, or volume through treatment; and short-term effectiveness). The overall effectiveness of all the alternatives was considered and then compared to each of their costs.

The estimated NPW of the Selected Remedy (Alternative 2) is $2,386,000. The NPW of Alternative 3 is approximately $170,000 less than for the Selected Remedy, and is generally equally effective at attaining the cleanup levels in the same time frame; however, it would result in the contamination remaining on site under a low permeability cap, requires long-term LUCs and O&M, and could interfere with future uses of the area.

2.13.4 Utilization of Permanent Solutions and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Practicable

NASA and USEPA, with VDEQ concurrence, have determined that the Selected Remedy Alternative 2 represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the Site. Of those alternatives that are protective of human health and the environment and comply with ARARs, NASA has determined that the Selected Remedy provides the best balance of trade-offs in terms of the five balancing criteria. NASA also considered the statutory preference for treatment as a principal element and state and community acceptance.

The Selected Remedy would remove all the contaminated soil and sediment from the Site. The contaminated soil and sediment that present a potential risk to human health under residential use and to the environment would be removed and disposed of in an off-site landfill. The Selected Remedy could be completed within two months. At the time of completion RAOs would be achieved with no risk remaining to human health or the environment. The Selected Remedy does not present short-term risks different than the other alternatives. There are no special implementability issues that set the Selected Remedy apart from any of the other alternatives evaluated.

2.13.5 Treatment as a Principal Element

Treatment is not a principal element of the Selected Remedy. Because of the small quantities of contaminated media and low concentrations of COCs, treatment processes would not be cost-effective and were not carried through the FS.

2.13.6 Five-Year Review Requirement

Because the Selected Remedy will not result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure, a five-year review will not be required for this remedial action.

2.14 DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan for the Skeet Range MRS at NASA WFF, Wallops Island, Virginia was released for public comment on April 3, 2023. The Proposed Plan identified Alternative 2, Excavation and Off-Site Disposal, as the preferred alternative. To fulfill CERCLA 117(b), 40 CFR 300.430(f)(5)(iii)(B) and 40 CFR 300.430(f)(3)(ii)(A) of the NCP, the ROD must document and discuss the reasons for any significant changes made to the Selected Remedy. Only one written or verbal comment was submitted during the public comment period. It was determined that no significant changes to the Selected Remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

3.0 RESPONSIVENESS SUMMARY

The Responsiveness Summary summarizes information about the views of the public and support agency regarding both the remedial alternatives and general concerns about the site submitted during the public comment period. Section 3.1 addresses those community concerns and comments that are non-technical in nature. Responses to specific legal and technical questions are provided in Section 3.2.

3.1 STAKEHOLDER COMMENTS AND LEAD AGENCY RESPONSES

The public comment period on the Proposed Plan for the Skeet Range Munitions Site was held from April 3 to May 3, 2023. Only one comment with two parts was received during this time and is summarized below.

Summary of Comments from Public Meeting and Public Comment Period

Comment	Response
Since the Skeet Range is in the area between the two runways in the northeast area of the base, then no action should be taken. If a new building is going in the area, then action should be taken at that time.	If no action is taken now, there would still be unacceptable risks to the environment from exposure to contaminated soil and sediment. Therefore, the removal of the contaminated soil at this time is an appropriate path forward.
Is contaminated soil being moved to an uncontaminated area?	Contaminated soil would not be taken to uncontaminated areas. In Alternative 2, the Selected Remedy, contaminated soil/sediment would be removed off site and disposed of at a permitted landfill. In Alternative 3, contaminated soil would be consolidated in one place with other pre-existing contaminated soil, not a new clean location.

3.2 TECHNICAL AND LEGAL ISSUES

No technical or legal issues associated with the Skeet Range Munitions Site ROD were identified.

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Tables

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TABLE 2-1
SUMMARY OF CHEMICALS OF CONCERN
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA

Medium/ Chemical	Receptors						
	Human Health		Ecological				
	Current/Future Industrial Workers	Future Hyptoethical Residents	Terrestrial Plants	Soil Invertebrates	Sediment Invertebrates	Birds	Mammals
HIGH TOWER RANGE EXPOSURE AREA							
Surface Soil							
Lead *	--	--	--	--	--	--	--
Lead Shot	--	--	--	--	--	X	--
Subsurface Soil							
Lead	--	--	--	--	--	--	--
NORTHERN RANGE EXPOSURE AREA							
Surface Soil							
Lead	X	X	X	X	X	X	--
Lead Shot **	--	--	--	--	--	--	--
Subsurface Soil							
Lead	--	X	--	--	--	--	--
SOUTHERN RANGE EXPOSURE AREA							
Surface Soil							
Lead	--	X	X	--	--	--	--
Lead Shot	--	--	--	--	--	X	--
Subsurface Soil							
Lead	--	--	--	--	--	--	--
SKEET RANGE SHOOTING EXPOSURE AREA							
Surface Soil							
Target PAHs	--	X	--	--	--	--	--
Lead Shot **	--	--	--	--	--	--	--
Subsurface Soil							
Target PAHs	--	X	--	--	--	--	--

Notes:

X - Chemical is retained as a risk-based Chemical of Concern (COC) to be addressed in the FS based on the risk assessments in and conclusions from the RI Report (Tetra Tech, 2020).

* The area average for lead is below the human health PRG of 200 mg/kg. However, some individual concentrations in surface soil exceed 200 mg/kg.

** Delineation of lead shot in the High Tower Range Area encroached into the western portion of the Northern Range Area. The Skeet Range Shooting Exposure Area is within the Southern Range Exposure Area, so lead shot encroaches into this area.

-- Samples in the Skeet Range Shooting Exposure Area were specific to PAH analysis; There is no unacceptable ecological risk associated with PAHs.

Seven Target PAHs for human health in this FS: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

TABLE 2-2
RESIDENTIAL HUMAN HEALTH RISK SUMMARY - SOUTHERN RANGE AND SKEET RANGE SHOOTING EXPOSURE AREAS
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA

		Incremental Lifetime Cancer Risk (ILCR)		Estimated Non-Carcinogenic Hazard Index (HI)		
Chemical	**EPC [1] (mg/kg)**	**Residential RSL [2] (mg/kg)**	**Estimated ILCR**	**Primary Target Organ**	**Residential RSL [2] (mg/kg)**	**Estimated HI**
Surface Soil						
Benzo(a)anthracene	9.57	1.1	9E-06	NA	NA	--
Benzo(a)pyrene	9	0.11	8E-05	Developmental, Immune, Reproductive	18	0.5
Benzo(b)fluoranthene	12.4	1.1	1E-05	NA	NA	--
Benzo(k)fluoranthene	3.7	11	3E-07	NA	NA	--
Dibenzo(a,h)anthracene	4.55	0.11	4E-05	NA	NA	--
Indeno(1,2,3-cd)pyrene	7.3	1.1	7E-06	NA	NA	--
Lead [3]	190	NA	--	NA	400	--
Total Cancer Risk			**2E-04**		**Total HI**	**0.50**
Subsurface Soil						
Benzo(a)anthracene	11.1	1.1	1E-05	NA	NA	--
Benzo(a)pyrene	9.78	0.11	9E-05	Developmental, Immune, Reproductive	18	0.5
Benzo(b)fluoranthene	13.9	1.1	1E-05	NA	NA	--
Dibenzo(a,h)anthracene	1.43	0.11	1E-05	NA	NA	--
Indeno(1,2,3-cd)pyrene	6.58	1.1	6E-06	NA	NA	--
Lead [3]	84.2	NA	--	NA	400	--
Total Cancer Risk			**1E-04**		**Total HI**	**0.50**

Notes:
mg/kg- Milligram per kilogram EPC - Exposure point concentration
RSL - Regional Screening Level NA- Not applicable ILCR - Incremental Lifetime Cancer Risk
ILCRs and HIs were calculated using a simple risk ratio technique, which divides the EPC by the RSL for residential exposure to soil and mulitiplies by the target risk level. For example, the ILCR for benzo(a)pyrene in surface soil was calculated as $(9.00 / 0.11) \times (1\times10^{-6}) = 8\times10^{-5}$. The HI for benzo(a)pyrene was calculated as $(9.00 / 18) \times (1) = 0.5$.
1. EPC is the 95% Upper Confidence Limit calculated by ProUCL Version 5.1.002.
2. USEPA RSL Table, November 2023. The non-carcinogenic values correspond to a target Hazard Quotient of 1. Carcinogenic values represent an ILCR of 1×10^{-6}.
3. Lead risks are evaluated separately using USEPA's Integrated Exposure Uptake Biokinetic (IEUBK) model and Adult Lead Model.

TABLE 2-3
INDUSTRIAL HUMAN HEALTH RISK SUMMARY - SOUTHERN RANGE AND SKEET RANGE SHOOTING EXPOSURE AREAS
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA

		Incremental Lifetime Cancer Risk (ILCR)		Estimated Non-Carcinogenic Hazard Index (HI)		
Chemical	**EPC [1] (mg/kg)**	**Industrial RSL [2] (mg/kg)**	**Estimated ILCR**	**Primary Target Organ**	**Industrial RSL [2] (mg/kg)**	**Estimated HI**
Surface Soil						
Benzo(a)anthracene	9.57	21	5E-07	NA	NA	--
Benzo(a)pyrene	9	2.1	4E-06	Developmental, Immune, Reproductive	220	0.04
Benzo(b)fluoranthene	12.4	21	6E-07	NA	NA	--
Benzo(k)fluoranthene	3.7	210	2E-08	NA	NA	--
Dibenzo(a,h)anthracene	4.55	2.1	2E-06	NA	NA	--
Indeno(1,2,3-cd)pyrene	7.3	21	3E-07	NA	NA	--
Lead [3]	190	NA	--	NA	800	--
Total Cancer Risk			**8E-06**		**Total HI**	**0.04**
Subsurface Soil						
Lead	84.2	NA	--	NA	800	--
Benzo(a)anthracene	11.1	21	5E-07	NA	NA	--
Benzo(a)pyrene	9.78	2.1	5E-06	Developmental, Immune, Reproductive	220	0.04
Benzo(b)fluoranthene	13.9	21	7E-07	NA	NA	--
Dibenzo(a,h)anthracene	1.43	2.1	7E-07	NA	NA	--
Indeno(1,2,3-cd)pyrene	6.58	21	3E-07	NA	NA	---
Total Cancer Risk			**7E-06**		**Total HI**	**0.04**

Notes:
mg/kg- Milligram per kilogram EPC - Exposure point concentration
RSL - Regional Screening Level NA- Not applicable ILCR - Incremental Lifetime Cancer Risk
ILCRs and HIs were calculated using a simple risk ratio technique, which divides the EPC by the RSL for residential exposure to soil and mulitiplies by the target risk level. For example, the ILCR for benzo(a)pyrene in surface soil was calculated as $(9.00 / 0.11) \times (1\times10^{-6}) = 8\times10^{-5}$. The HI for benzo(a)pyrene was calculated as $(9.00 / 18) \times (1) = 0.5$.
1. EPC is the 95% Upper Confidence Limit calculated by ProUCL Version 5.1.002.
2. USEPA RSL Table, November 2023. The non-carcinogenic values correspond to a target Hazard Quotient of 1. Carcinogenic values represent an ILCR of 1×10^{-6}.
3. Lead risks are evaluated separately using USEPA's Integrated Exposure Uptake Biokinetic (IEUBK) model and Adult Lead Model.

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TABLE 2-4
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - DIRECT CONTACT SKEET RANGE MRS
NASA WALLOPS FLIGHT FACILITY WALLOPS ISLAND, VIRGINIA

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Sample of Maximum Concentration	Frequency of Detection	Range of Nondetects[2]	Concentration Used for Screening[3]	Range of Background Concentrations[4]	USEPA RSL[5]	Potential ARAR/TBC	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection[6]
Northern Range Area	**Polycyclic Aromatic Hydrocarbons**														
	56-55-3	Benzo(a)anthracene	3.7 J	14 J	ug/kg	SR-SS-039-000.5-20071019	5/5	-	14	NA	1,100 C	NA	NA	No	BSL
	50-32-8	Benzo(a)pyrene	4.4 J	13 J	ug/kg	SR-SS-037-000.5-20071019, SR-SS-038-000.5-20071019	4/5	100 - 100	13	NA	110 C	NA	NA	No	BSL
	205-99-2	Benzo(b)fluoranthene	6.5 J	22 J	ug/kg	SR-SS-038-000.5-20071019	4/5	100 - 100	22	NA	1,100 C	NA	NA	No	BSL
	191-24-2	Benzo(g,h,i)perylene	4.5 J	11 J	ug/kg	SR-SS-037-000.5-20071019	4/5	100 - 100	11	NA	180,000 $_{nc}$	NA	NA	No	BSL
	207-08-9	Benzo(k)fluoranthene	3.7 J	11 J	ug/kg	SR-SS-038-000.5-20071019	4/5	100 - 100	11	NA	11,000 C	NA	NA	No	BSL
	218-01-9	Chrysene	4.7 J	18 J	ug/kg	SR-SS-039-000.5-20071019	5/5	-	18	NA	110,000 C	NA	NA	No	BSL
	53-70-3	Dibenzo(a,h)anthracene	9.4 J	9.4 J	ug/kg	SR-SS-038-000.5-20071019	1/5	21 - 100	9.4	NA	110 C	NA	NA	No	BSL
	206-44-0	Fluoranthene	7.4 J	25 J	ug/kg	SR-SS-039-000.5-20071019	5/5	-	25	NA	240,000 N	NA	NA	No	BSL
	193-39-5	Indeno(1,2,3-cd)pyrene	5 J	11 J	ug/kg	SR-SS-037-000.5-20071019, SR-SS-038-000.5-20071019	4/5	100 - 100	11	NA	1,100 C	NA	NA	No	BSL
	85-01-8	Phenanthrene	5.7 J	5.7 J	ug/kg	SR-SS-037-000.5-20071019	1/5	21 - 100	5.7	NA	180,000 $_{nc}$	NA	NA	No	BSL
	Miscellaneous Parameters														
	7439-92-1	**Lead**	104	22,200	mg/kg	SR-SS-213-0006	35/35	-	22,200	NA	$_{200}$ [7]	NA	NA	**Yes**	ASL
	--	pH	5.6	6.2	S.U.	SR-SS-006-000.5-20071019, SR-SS-038-000.5-20071019	5/5	-	6.2	NA	NA	NA	NA	No	NTX
	--	Total Organic Carbon	20,000	360,000 J	mg/kg	SR-SS-039-000.5-20071019	5/5	-	360,000	NA	NA	NA	NA	No	NTX

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Sample of Maximum Concentration	Frequency of Detection	Range of Nondetects[2]	Concentration Used for Screening[3]	Range of Background Concentrations[4]	USEPA RSL[5]	Potential ARAR/TBC	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection[6]
Northern Range Area	**Miscellaneous Parameters**														
	7439-92-1	**Lead**	13	846	mg/kg	SR-SS-201-0612	25/25	-	846	NA	$_{200}$ [7]	NA	NA	**Yes**	ASL

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Sample of Maximum Concentration	Frequency of Detection	Range of Nondetects[2]	Concentration Used for Screening[3]	Range of Background Concentrations[4]	USEPA RSL[5]	Potential ARAR/TBC	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection[6]
Southern Range Area	**Polycyclic Aromatic Hydrocarbons**														
	91-57-6	2-Methylnaphthalene	3.2 J	120 J	ug/kg	SR-SS-033-000.5-20071025	16/45	21 - 26	120	NA	24,000 N	NA	NA	No	BSL
	83-32-9	Acenaphthene	2 J	670	ug/kg	SR-SS-033-000.5-20071025	25/45	21 - 25	670	NA	360,000 N	NA	NA	No	BSL
	120-12-7	Anthracene	2.9 J	2,800	ug/kg	SR-SS-033-000.5-20071025	27/45	21 - 25	2,800	NA	1,800,000 N	NA	NA	No	BSL
	56-55-3	**Benzo(a)anthracene**	3.1 J	60,000	ug/kg	SR-SS-267-0006-D	70/70	-	60,000	NA	**1,100 C**	NA	NA	**Yes**	ASL
	50-32-8	**Benzo(a)pyrene**	3.7 J	49,000	ug/kg	SR-SS-267-0006-D	69/70	23 - 23	49,000	NA	**110 C**	NA	NA	**Yes**	ASL
	205-99-2	**Benzo(b)fluoranthene**	4.9 J	72,000	ug/kg	SR-SS-267-0006-D	67/70	22 - 24	72,000	NA	**1,100 C**	NA	NA	**Yes**	ASL
	191-24-2	Benzo(g,h,i)perylene	4.2 J	24,000	ug/kg	SR-SS-008-000.5-20071022	40/45	22 - 24	24,000	NA	180,000 $_{nc}$	NA	NA	No	BSL
	207-08-9	**Benzo(k)fluoranthene**	3.6 J	23,000	ug/kg	SR-SS-267-0006	65/70	3.1 - 24	23,000	NA	**11,000 C**	NA	NA	**Yes**	ASL
	218-01-9	Chrysene	3 J	61,000	ug/kg	SR-SS-267-0006-D	65/70	1.7 - 24	61,000	NA	110,000 C	NA	NA	No	BSL
	53-70-3	**Dibenzo(a,h)anthracene**	2 J	12,000	ug/kg	SR-SS-267-0006-D, SR-SS-275-0006	56/70	1.8 - 25	12,000	NA	**110 C**	NA	NA	**Yes**	ASL
	206-44-0	Fluoranthene	5.4 J	36,000	ug/kg	SR-SS-033-000.5-20071025	45/45	-	36,000	NA	240,000 N	NA	NA	No	BSL
	86-73-7	Fluorene	2.9 J	380	ug/kg	SR-SS-033-000.5-20071025	22/45	21 - 25	380	NA	240,000 N	NA	NA	No	BSL
	193-39-5	**Indeno(1,2,3-cd)pyrene**	5.4 J	38,000	ug/kg	SR-SS-275-0006	64/70	22 - 24	38,000	NA	**1,100 C**	NA	NA	**Yes**	ASL
	91-20-3	Naphthalene	4.1 J	370	ug/kg	SR-SS-033-000.5-20071025	22/45	21 - 25	370	NA	2,000 C	NA	NA	No	BSL
	85-01-8	Phenanthrene	5.8 J	12,000	ug/kg	SR-SS-033-000.5-20071025	34/45	21 - 24	12,000	NA	180,000 $_{nc}$	NA	NA	No	BSL
	129-00-0	Pyrene	9.6 J	30,000 J	ug/kg	SR-SS-008-000.5-20071022	31/45	21 - 25	30,000	NA	180,000 N	NA	NA	No	BSL
	Miscellaneous Parameters														
	7439-92-1	**Lead**	5.43	1,140	mg/kg	SR-SS-235-0006	76/76	-	1,140	NA	$_{200}$ [7]	NA	NA	**Yes**	ASL
	--	pH	4.7	8.7	S.U.	SR-SS-051-000.5-20071107	45/45	-	8.7	NA	NA	NA	NA	No	NTX
	--	Total Organic Carbon	3400	60,000	mg/kg	SR-SS-029-000.5-20071024	45/45	-	60,000	NA	NA	NA	NA	No	NTX

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Sample of Maximum Concentration	Frequency of Detection	Range of Nondetects[2]	Concentration Used for Screening[3]	Range of Background Concentrations[4]	USEPA RSL[5]	Potential ARAR/TBC	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection[6]
Southern Range Area	**Polycyclic Aromatic Hydrocarbons**														
	56-55-3	**Benzo(a)anthracene**	3.9 J	16,000	ug/kg	SR-SS-275-0612	16/16	-	16,000	NA	**1,100 C**	NA	NA	**Yes**	ASL
	50-32-8	**Benzo(a)pyrene**	4.2 J	14,000	ug/kg	SR-SS-275-0612	16/16	-	14,000	NA	**110 C**	NA	NA	**Yes**	ASL
	205-99-2	**Benzo(b)fluoranthene**	6.1 J	20,000	ug/kg	SR-SS-275-0612	16/16	-	20,000	NA	**1,100 C**	NA	NA	**Yes**	ASL
	207-08-9	Benzo(k)fluoranthene	5.7 J	5,500	ug/kg	SR-SS-275-0612	15/16	3.1 - 3.4	5,500	NA	11,000 C	NA	NA	No	BSL
	218-01-9	Chrysene	18 J	16,000	ug/kg	SR-SS-275-0612	15/16	-	16,000	NA	110,000 C	NA	NA	No	BSL
	53-70-3	**Dibenzo(a,h)anthracene**	4.4 J	3,000	ug/kg	SR-SS-275-0612	15/16	1.9 - 1.9	3,000	NA	**110 C**	NA	NA	**Yes**	ASL
	193-39-5	**Indeno(1,2,3-cd)pyrene**	4.2 J	9,300	ug/kg	SR-SS-275-0612	16/16	-	9,300	NA	**1,100 C**	NA	NA	**Yes**	ASL
	Miscellaneous Parameters														
	7439-92-1	**Lead**	2.22	728	mg/kg	SR-SS-221-0612 SIEVE 20	44/44	-	728	NA	$_{200}$ [7]	NA	NA	**Yes**	ASL

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Sample of Maximum Concentration	Frequency of Detection	Range of Nondetects[2]	Concentration Used for Screening[3]	Range of Background Concentrations[4]	USEPA RSL[5]	Potential ARAR/TBC	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection[6]
High Tower Range Area	**Polycyclic Aromatic Hydrocarbons**														
	120-12-7	Anthracene	3.6 J	3.6 J	ug/kg	SR-SS-005-000.5-20071018	1/1	-	3.6	NA	1,800,000 N	NA	NA	No	BSL
	56-55-3	Benzo(a)anthracene	22 J	22 J	ug/kg	SR-SS-005-000.5-20071018	1/1	-	22	NA	1,100 C	NA	NA	No	BSL
	50-32-8	Benzo(a)pyrene	20 J	20 J	ug/kg	SR-SS-005-000.5-20071018	1/1	-	20	NA	110 C	NA	NA	No	BSL
	205-99-2	Benzo(b)fluoranthene	20 J	20 J	ug/kg	SR-SS-005-000.5-20071018	1/1	-	20	NA	1,100 C	NA	NA	No	BSL
	191-24-2	Benzo(g,h,i)perylene	14 J	14 J	ug/kg	SR-SS-005-000.5-20071018	1/1	-	14	NA	180,000 $_{nc}$	NA	NA	No	BSL
	207-08-9	Benzo(k)fluoranthene	13 J	13 J	ug/kg	SR-SS-005-000.5-20071018	1/1	-	13	NA	11,000 C	NA	NA	No	BSL
	218-01-9	Chrysene	20 J	20 J	ug/kg	SR-SS-005-000.5-20071018	1/1	-	20	NA	110,000 C	NA	NA	No	BSL
	206-44-0	Fluoranthene	31	31	ug/kg	SR-SS-005-000.5-20071018	1/1	-	31	NA	240,000 N	NA	NA	No	BSL
	193-39-5	Indeno(1,2,3-cd)pyrene	16 J	16 J	ug/kg	SR-SS-005-000.5-20071018	1/1	-	16	NA	1,100 C	NA	NA	No	BSL
	85-01-8	Phenanthrene	13 J	13 J	ug/kg	SR-SS-005-000.5-20071018	1/1	-	13	NA	180,000 $_{nc}$	NA	NA	No	BSL
	129-00-0	Pyrene	21	21	ug/kg	SR-SS-005-000.5-20071018	1/1	-	21	NA	180,000 N	NA	NA	No	BSL
	Miscellaneous Parameters														
	7439-92-1	**Lead**	7.87	508	mg/kg	SR-SS-254-0006	17/17	-	508	NA	$_{200}$ [7]	NA	NA	**Yes**	ASL
	--	pH	6	6	S.U.	SR-SS-005-000.5-20071018	1/1	-	6	NA	NA	NA	NA	No	NTX
	--	Total Organic Carbon	17,000	17,000	mg/kg	SR-SS-005-000.5-20071018	1/1	-	17,000	NA	NA	NA	NA	No	NTX

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Sample of Maximum Concentration	Frequency of Detection	Range of Nondetects[2]	Concentration Used for Screening[3]	Range of Background Concentrations[4]	USEPA RSL[5]	Potential ARAR/TBC	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection[6]
High Tower Range Area	**Miscellaneous Parameters**														
	7439-92-1	Lead	4.68 J	176 J	mg/kg	SR-SS-255-0612	21/21	-	176	NA	$_{200}$ [7]	NA	NA	No	BSL

(1) Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
(2) Values presented are sample-specific quantitation limits.
(3) The maximum detected concentration is used for screening purposes.
(4) No background data is available.
(5) USEPA Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites, November 2023. The noncarcinogenic values (denoted with a "N" flag) correspond to a target hazard quotient of 0.1. Carcinogenic values represent an incremental cancer risk of 1E-06 (carcinogens denoted with a "C" flag).
(6) The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level.
(7) USEPA, 2016. Updated Scientific Considerations for Lead in Soil Cleanups, December.
(8) Value is for pyrene.

The maximum detected concentration exceeds one or more screening criteria. Shaded chemical name indicates that the chemical was retained as a COPC.

Definitions:

ARAR	Applicable/Relevant and Appropriate Requirements
TBC	To Be Considered
C	Carcinogen
CAS	Chemical Abstracts Service
COPC	Chemical Of Potential Concern
J	Estimated value
mg/kg	milligrams per kilogram
N	Noncarcinogen
NA	Not Applicable/Not Available

Rationale Codes:

For selection as a COPC:
ASL Above Screening Level

For elimination as a COPC:
BSL Below COPC Screening Level
NTX No toxicity criteria

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TABLE 2-5
PRELIMINARY REMEDIATION GOAL SUMMARY
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA

Medium[1]	COCs	Human Health PRGs[2]		Ecological PRGs[2]			Background Values[3]				Selected PRG	Basis
		Residential	Industrial	Terrestrial Plants	Birds	Sediment Invetebrates	Molena Surface Soil	Molena Subsurface Soil	Bojak Surface Soil	Bojak Subsurface Soil		
Surface Soil	Lead (*average*)[4] (mg/kg)	200	200	240	299	NA	30.6	16.4	21.1	13.3	200	Blood lead level < 5 µg/dL for residential child and fetus of pregnant adult worker
	Lead (*not-to-exceed*) (mg/kg)	NA	NA	750	1,100	NA	30.6	16.4	21.1	13.3	750	NOAEC for rye grass
	Lead Shot (*not-to-exceed*) (LS/foot^2)	NA	NA	NA	100	NA	NA	NA	NA	NA	100	Ingestion probability modeling for mourning dove
	Target PAHs (*TCR*)[5]	1×10^{-4}	NA	NA	NA	NA	NA	NA	NA	NA	1×10^{-4}	Residential ILCR < 1×10^{-4}
Subsurface Soil	Lead (*average*)[4] (mg/kg)	200	200	NA	NA	NA	30.6	16.4	21.1	13.3	200	Blood lead level < 5 µg/dL for residential child and fetus of pregnant adult worker
	Target PAHs (*TCR*)[5]	1×10^{-4}	NA	NA	NA	NA	NA	NA	NA	NA	1×10^{-4}	Residential ILCR < 1×10^{-4}
Sediment	Lead (*not-to-exceed*)[6] (mg/kg)	NA	NA	NA	NA	530	NA	NA	NA	NA	530	Washington State Sediment Management Standards sediment cleanup screening level

Notes
COC - Chemical of Concern
mg/kg- milligrams per kilogram
LS/foot^2 - Lead shot per square foot
TCR - Target cancer risk
PRG - Preliminary Remediation Goal
NA - Not applicable
PAH - Polycyclic aromatic hydrocarbon
ILCR - Incremental lifetime cancer risk
NOAEC - No observed adverse effects concentration

1. The surface soil and sediment media of concern addressed in the FS correspond to depth interval of 0 to 1 foot bgs. The subsurface soil medium of concern in the FS corresponds to a depth interval of 1 to 2 feet bgs.
2. See Table 1-1 for explanation of PRG candidates from the Tetra Tech (2020) Remedial Investigation (RI) Report. Also, see Appendix A of the Tetra Tech (2018a) Sampling and Analysis Plan for the RI.
3. Values for Molena and Bojak soils from Background Soil and Groundwater Investigation Report (Tetra Tech, 2004). Background data/values are being reevaluated separately at the time of this FS.
   Draft background values in December 2020 are 84.8 and 12.2 mg/kg for Molena surface and subsurface soils and 19.5 and 10.2 mg/kg for Bojak surface and subsurface soils, respectively.
4. Arithmetic mean lead concentration in the respective depth interval across the soil exposure unit (Northern Range, Southern Range, and High Tower Range Exposure Areas).
5. TCR not-to-exceed-PRG of 1×10^{-4} at any sample/location for the seven target PAH COCs: Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.
6. Sediment PRG applies to the palustrine forested wetland in the low-lying drainage area of the Northern Range Exposure Area. This value is more stringent than the 750 mg/kg value for surface and shallow subsurface soils throughout the site.

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TABLE 2-6
ASSESSMENT ENDPOINTS AND MEASUREMENT ENDPOINTS
SKEET RANGE MRS
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

Assessment Endpoint	Measurement Endpoint
Adverse effects on the survival, reproduction, and/or growth of soil invertebrates	• Survival, growth, and/or reproduction of soil invertebrates were evaluated by comparing the measured concentrations of chemicals in the surface soil to invertebrate soil screening levels.
Adverse effects on the survival, reproduction, and/or growth of terrestrial plants	• Survival, growth, and/or reproduction of terrestrial plants were evaluated by comparing the measured concentrations of chemicals in the surface soil to plant soil screening levels.
Adverse effects on the survival, reproduction, and/or growth of sediment invertebrates	• Survival, growth, and/or reproduction of sediment invertebrates were evaluated by comparing the measured concentrations of chemicals in the sediment to sediment screening levels.
Adverse effects on the survival, reproduction, and/or increase in development effects of herbivorous birds and mammals	• Survival, reproduction, and/or increase in development effects of birds and mammals were evaluated by comparing the estimated ingested dose of contaminants in the surface soil and vegetation to No Observed Adverse Effects Levels (NOAELs) and Lowest Observed Adverse Effects Levels (LOAELs) for surrogate wildlife species.
Adverse effects on the survival, reproduction, and/or increase in development effects of invertivorous birds and mammals	• Survival, reproduction, and/or increase in development effects of birds and mammals were evaluated by comparing the estimated ingested dose of contaminants in the surface soil and earthworms to NOAELs and LOAELs for surrogate wildlife species.

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TABLE 2-7
SUMMARY OF FEDERAL AND STATE ARARs
CHEMICAL SPECIFIC
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA

Requirement	Citation	Status	Synopsis of Requirement	Compliance Actions
Federal				
USEPA Human Health Assessment Cancer Slope Factors (CSFs)	None	TBC for Alternatives 1, 2, and 3	Guidance values used to evaluate the potential carcinogenic hazards caused by exposure to contaminants.	Human health risks from exposure to PAHs, as assessed with CSFs, are used to evaluate exposures to carcinogenic contaminants in site media and, in this case, develop site-specific target-cancer-risk-based PRGs. The limits of the PAH-related Attainment Areas (AA)s and Target Remediation Zones (TRZs) for both Alternatives 2 and 3 are based calculated risk exceedances of the target-cancer-risk-based-PRG of 1×10^{-4} for the seven target PAHs at a sample locations during the Remedial Investigation(1). Benzo(a)pyrene, one of the seven target PAHs, also has non-cancer toxic effects, but they are below the threshold requiring action (i.e., calculated Hazard Index is less than 1); addressing benzo(a)pyrene based on risk levels determined using its CSF is more conservative in this case. Alternative 1–No action would not comply with this TBC as no actions or efforts would be taken to address PAHs to meet the risk-based cleanup level or to monitor their concentrations and associated risks.

TABLE 2-7
SUMMARY OF FEDERAL AND STATE ARARs
CHEMICAL SPECIFIC
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA

Requirement	Citation	Status	Synopsis of Requirement	Compliance Actions
USEPA Guidance Document(s) on human health protective levels for lead in soil and in the blood.	USEPA (1994a, 1994b, 2003a, 2007, 2010, 2016, 2017a, 2017b, and 2024)	TBC for Alternatives 1, 2, and 3	USEPA guidance documents and advisories for evaluating risks to adults and children posed by lead in soil.	Risks from lead assessed under these guidance documents will be addressed through remediation measures. The average-PRG of 200 mg/kg is developed with USEPA's IEUBK and Adult Lead Model methodology such that blood lead levels are less than the most recently recommended 5 µg/dL in less than 5% of the population (children and the fetuses of pregnant workers). The limits of the lead-related AAs/TRZs for Alternatives 2 and 3 are based on addressing lead concentrations in each exposure area such that the remaining average lead concentrations is less than 200 mg/kg. This human health lead PRG is more conservative than the ecological lead PRG candidates. Alternative 1–No action would not comply with this TBC as no actions or efforts would be taken to address lead to meet the cleanup levels or to monitor their concentrations and associated toxic effects to human receptors.

TABLE 2-7
SUMMARY OF FEDERAL AND STATE ARARs
CHEMICAL SPECIFIC
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA

Requirement	Citation	Status	Synopsis of Requirement	Compliance Actions
USEPA Ecological Soil Screening Level (SSL) literature-based study benchmarks and values (e.g., LOEC and LOAEL)	USEPA (2020), Guy et al. (2004), Washington State Department of Ecology (2013)	TBC for Alternatives 1, 2, and 3	Guidance and empirically-based literature values and processes used to evaluate risks to ecological receptors caused by exposure to contaminants.	Ecological SSLs and other literature-based values and food chain models are used to evaluate exposure risks from lead to terrestrial plants, soil invertebrates, sediment invertebrates, insectivorous birds and mammals, and herbivorous birds and mammals. Several PRG candidates for lead are developed for each receptor in soil or sediment based on various values, including average- and not-to-exceed-PRGs. Soil or dry sediment in the low-lying drainage area and palustrine forested wetland in the Northern Range Exposure Area was evaluated as sediment in the ERA. Alternative 1–No action would not comply with this TBC as no actions or efforts would be taken to address lead to meet the cleanup levels or to monitor their concentrations and associated toxic effects to ecological receptors.

TABLE 2-7
SUMMARY OF FEDERAL AND STATE ARARs
CHEMICAL SPECIFIC
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA

Requirement	Citation	Status	Synopsis of Requirement	Compliance Actions
Ecological lead shot ingestion probability modeling	USEPA-recommended Bennett et al. (2011) model	TBC for Alternatives 2 and 3	Guidance and probability model used to evaluate risks to birds from ingesting grit and lead shot.	Ingestion probability modeling was used to evaluate risks to birds and to develop the lead shot PRG for soil. Modeling was performed with USEPA-recommended Bennett et al.'s (2011) ingestion probability model using the lead shot count and soil sieve results. Because the habitat (i.e., High Tower Range and Southern Range Exposure Areas for lead shot) is not a wildlife refuge or other type of sensitive environment, a probability of 20% that a bird would ingest one lead shot was the basis of the recommended lead shot PRG of 100 lead shot per square foot (LS/ft^2) developed during the Remedial Investigation (RI). The probability modeling was conducted for all three ecological depth intervals (i.e., 0-6, 6-12, and 12-24 inches) to determine unacceptable risks to birds in the Ecological Risk Assessment (ERA) during the RI, although the primary lead shot exposure for birds would be in the top 6 inches. Based on the modeling results, the lead shot PRG is applied to the 0- to 1-foot depth interval for the lead-shot-related AAs/TRZs in the High Tower and Southern Range Exposure Areas.
State				
There are no Commonwealth of Virginia chemical-specific ARARs for the alternatives under evaluation.				

TABLE 2-7
SUMMARY OF FEDERAL AND STATE ARARs
LOCATION-SPECIFIC
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA

Requirement	Citation	Status	Synopsis of Requirement	Compliance Action
Federal				
Archaeological and Historic Preservation Act	36 CFR Part 62 and 65	Applicable to Alternatives 2 and 3	Establishes requirements relating to potential loss or destruction of significant scientific, historical, or archaeological data. Also requires federal agencies to consider to existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	The Skeet Range Munitions Response Site (MRS) overlaps with Potential or Eligible areas of effect. Therefore, on-site archaeological support would be required during clearing and excavations under Alternatives 2 and 3; an archaeological sensitive assessment deliverable would be produced after construction and included in the construction completion report-type document.

TABLE 2-7
SUMMARY OF FEDERAL AND STATE ARARs
LOCATION-SPECIFIC
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA

Requirement	Citation	Status	Synopsis of Requirement	Compliance Action
Endangered Species Act (ESA) of 1973	Section 7(a)(2) of ESA; 50 CFR 17.21 and 17.31; 50 CFR 402.12	Applicable to Alternatives 2 and 3	This act requires federal agencies to act to avoid undertaking, funding, permitting or authorizing actions that are likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat in the construction "Action Area." A biological assessment shall evaluate the potential effects of the action on listed and proposed species and designated and proposed critical habitat and determine whether any such species or habitat are likely to be adversely affected by the action and is used in determining whether formal consultation or a conference is necessary.	A review of the available information indicates several possible state or federally listed endangered or threatened species that may permanently or seasonally reside in portions of the Skeet Range MRS. While the habitat-assessment-site-visit during the RI did not observe any, a Biological Evaluation (or biological opinion) will be prepared and submitted to USFWS for review for the anticipated Action Area. Continual observations also would occur throughout the remedial action under any of the alternatives.
Coastal Zone Management Act	15 CFR 923.53	Applicable to Alternatives 2 and 3	This act requires federal agencies to ensure that, if a "Proposed Action" will have reasonably foreseeable effects on coastal resources, then the action must be consistent with the state's coastal zone management program.	Activities for both Alternatives 2 and 3 are within Virginia's Coastal Zone. NASA will review which enforceable policies [of Virginia's NOAA-approved Coastal Zone Management Program] apply based on a review of the Proposed Action's effects on coastal zone uses and resources. This is partially reliant on the results of the Biological Evaluation (see above).

TABLE 2-7
SUMMARY OF FEDERAL AND STATE ARARs
LOCATION-SPECIFIC
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA

Requirement	Citation	Status	Synopsis of Requirement	Compliance Action
Fish and Wildlife Coordination Act	16 United States Code (USC) 661-663	Applicable to Alternatives 2 and 3	Requires that the USFWS, National Marine Fisheries Service, and related state agencies be consulted prior to structural modification of any body of water, including wetlands. If modifications must be conducted, the regulation requires that adequate protection be provided for fish and wildlife resources.	This regulation will serve as guidance during the excavation in the High Tower and Northern Range Exposure Areas: TRZ LS1 uphill from the wetland drainage area, TRZ L1 soil in the upland drainage area, and TRZ L1 Sediment in the palustrine forested wetland habitat. Appropriate erosion and sediment (E&S) control measures and spill prevention measures will be implemented under Alternatives 2 and 3.
Protection of Wetlands	Executive Order (EO)11990	TBC for Alternatives 2 and 3	EO 11990 requires that for all projects, all agencies shall take action to minimize the destruction, loss, or degradation of wetlands. The project must include all practicable measures to minimize harm to wetlands	This EO will serve as guidance during the excavation in the Northern Range Exposure Area under Alternatives 2 and 3. TRZ L1 Sediment is the 1,700-square foot (0.04-acre) soil/sediment area to be excavated from the palustrine forested wetland habitat. The area will be backfilled with loamy fill and likely allowed to revegetate naturally. No net loss of habitat.
Floodplain Management	Executive Order 11988	Applicable to Alternatives 2 and 3	Executive Order 11988 requires that projects avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains.	The northern part of the Skeet Range MRS is in a flood zone. After the excavation in the Northern Range Exposure Area under both Alternatives 2 and 3, site restoration activities would be conducted to restore and preserve the flood plains.

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SUMMARY OF FEDERAL AND STATE ARARs
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Requirement	Citation	Status	Synopsis of Requirement	Compliance Action
Discharge of Dredged or Fill Material into Waters of the United States, Clean Water Act (CWA) Part 404(b)(1)	40 CFR 230.10 (Restrictions on Discharge), 230.41 (Wetlands), 230.93 (General Compensatory Mitigation Requirements),	Applicable to Alternatives 2 and 3	During the identification, screening, and evaluation of alternatives, the effects on wetlands will be evaluated. Adverse impacts on wetlands will be avoided if possible. No activity that adversely affects a wetland shall be permitted if a practicable alternative that has less effect is available. If there is no other practicable alternative, impacts must be mitigated.	USACE or designee will be consulted regarded any actions that affect wetlands. The 1,700-square foot (0.04-acre) portion of palustrine forested wetland to be impacted by excavation under both Alternatives 2 and 3 is part of a presumably jurisdictional wetland based on the evaluation performed during the Remedial Investigation. USACE will be consulted prior to any remedial action. No net loss of habitat.
State				
Coastal Zone Management	Virginia Coastal Zone Management Program	Applicable to Alternatives 2 and 3	Virginia's federally approved Coastal Zone Management Program authorizes VDEQ to require that coastal zone actions are consistent with state laws and enforceable policies.	See above for the federal Coastal Zone Management Act ARAR discussion. Activities for both Alternatives 2 and 3 are within Virginia's Coastal Management Zone. NASA will ensure that any Proposed Action's effects on coastal zone uses and resources will be consistent with Virginia Coastal Zone Management Program's enforceable policies.

TABLE 2-7
SUMMARY OF FEDERAL AND STATE ARARs
LOCATION-SPECIFIC
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Requirement	Citation	Status	Synopsis of Requirement	Compliance Action
Wetlands Mitigation–Compensation Policy	4 VAC 20-390	Applicable to Alternatives 2 and 3	This policy encourages, where appropriate, the compensation of all permitted tidal wetland losses, especially vegetated losses, provided all mitigative measures have been considered to avoid any impact. This should include compensation on-site, compensation within the watershed, compensation through the use of a mitigation bank, or payment to an in-lieu fee account.	Excavation in the drainage area in the Northern Range Exposure Area under Alternatives 2 and 3 will temporarily impact a 1,700-square foot (0.04-acre) portion of the palustrine forested wetland habitat. The area will be backfilled with loamy fill and allowed to revegetate naturally. No net loss of habitat.
Wetlands Policy	9 VAC 25-380	Applicable to Alternatives 2 and 3	These regulations contain procedures and restrictions for siting water treatment plants, controlling construction activities, and controlling non-point sources to prevent discharges which will impair the quality of a wetland area. Alteration in quantity or quality of the natural flow of water, which nourishes the ecosystem, should be minimized.	A 1,700-square foot (0.04-acre) portion of the palustrine forested wetland habitat would be impacted temporarily during sediment excavation in TRZ L1 Sediment in the Northern Range Exposure Area under both Alternatives 2 and 3. Appropriate E&S controls will be used during construction activities and removed when restoration metrics are met.
Water Resources Policy	9 VAC 25-390	Applicable to Alternatives 2 and 3	This policy restricts construction in floodplains, and requires minimizing the destruction, loss, or degradation of wetlands and surface water resources to assure water quality and quantity (i.e., Virginia's water resources) needs are always met.	A 1,700-square foot (0.04-acre) portion of the palustrine forested wetland habitat would be impacted temporarily during sediment excavation in TRZ L1 Sediment in the Northern Range Exposure Area under both Alternatives 2 and 3. The area will be backfilled with loamy fill and allowed to revegetate naturally.

TABLE 2-7
SUMMARY OF FEDERAL AND STATE ARARs
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Requirement	Citation	Status	Synopsis of Requirement	Compliance Action
Endangered and Threatened Species	4 VAC 15-20-130	Applicable to Alternatives 2 and 3	These regulations from the Department of Game and Inland Fisheries prohibit the taking of endangered species. The cited regulations provide listings of endangered species and definitions of actions which constitute taking.	A review of the available information indicates several possible state or federally listed endangered or threatened species that may permanently or seasonally reside in portions of the Skeet Range MRS. While the habitat-assessment-site-visit during the RI did not observe any, a biological opinion will be prepared and submitted under the federal regulation to the regional USFWS for review for the anticipated Action Area due to working in and near the wetland and forested areas under both Alternatives 2 and 3. Continual observations also would occur throughout the remedial action under any of the alternatives.
Endangered Plant and Insect Species Act Regulations	2 VAC 5-320	Applicable to Alternatives 2 and 3	These regulations from the Virginia Department of Game and Inland Fisheries prohibit the taking of endangered plant and insect species.	A review of the available information does not indicate any state listed endangered or threatened plant and insect species at the Skeet Range MRS. While the habitat-assessment-site-visit during the RI did not observe any, the federal biological opinion referenced above will further evaluate their presence. Continual observations also would occur throughout the remedial action under any of the alternatives.

TABLE 2-7
SUMMARY OF FEDERAL AND STATE ARARs
ACTION-SPECIFIC
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Requirement	Citation	Status	Synopsis of Requirement	Compliance Action
Federal				
Clean Water Act - National Pollutant Discharge Elimination System (NPDES)	40 CFR 122.26	Relevant and Appropriate for Alternatives 2 and 3	Runoff quality and sediment discharges from construction projects with earth disturbance must be controlled.	No intentional discharge to surface water bodies will take place under Alternative 2 or Alternative 3 at the Skeet Range Munitions Response Site (MRS). An erosion and sediment (E&S) control plan will be implemented and adhered to during all excavation activities to mitigate risks from surface water runoff and work within and near the palustrine forested wetland. These requirements will be met by following the substantive requirements of a NPDES Stormwater construction permit. Disturbances greater than or equal to 5 acres are classified as Large, and disturbances less than 5 acres (Alternatives 2 and 3) are classified as Small. Virginia is an NPDES-authorized state, so Virginia's rules would be used. The E&S controls will not be removed until permanent controls (revegetation) are established.
RCRA Regulations, Hazardous Waste Determination	40 CFR Part 262.11 (a) through (e)	Applicable to Alternatives 2 and 3	Defines method to determine if a solid waste is a hazardous waste. Virginia is a RCRA-authorized state and incorporates the federal regulations (with some revisions) by reference. The federal regulations are listed here for clarity.	Pre-construction TCLP samples will be collected for waste characterization to determine appropriate lead treatment prior to covering on-site (Alternative 3) or off-site transportation and disposal (Alternative 2). The on-site lead leachability treatment component (if needed) would stabilize lead in soils and render the material nonhazardous by characteristic, and, hence, allow for placement on-site under a soil cover (Alternative 3) or nonhazardous off-site transportation and disposal. TCLP samples would be collected after treatment to confirm the nonhazardous characteristic for lead has been achieved.

TABLE 2-7
SUMMARY OF FEDERAL AND STATE ARARs
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Requirement	Citation	Status	Synopsis of Requirement	Compliance Action
Management of Remediation Waste Under RCRA – Area of Contamination (AOC) Policy	USEPA 530-F-98-026 (October 1998)	TBC for Alternatives 2 and 3	This policy describes how remediation wastes can be handled and treated on-site without triggering other RCRA ARARs.	The AOC policy allows wastes to be consolidated or treated within an AOC (i.e., site) without triggering land disposal restrictions or minimum technology requirements. Lead-contaminated soils can be treated in situ or in staged areas within the site (if needed) prior to covering (Alternative 3) or off-site transportation and disposal as nonhazardous waste (Alternative 2).
Subtitle D Solid Waste Landfills – Final Cover	40 CFR 258.60 (a), (b), and (c)	Relevant and Appropriate for Alternative 3	Establishes design and operating criteria for solid waste [nonhazardous] landfills.	The closure and post-closure care requirements under RCRA Subtitle D may be relevant and appropriate for Alternative 3 within the limits of site. The covering of in situ contamination and consolidated excavated contamination with a vegetative soil cover requires post-construction periodic O&M and LUC inspections. These requirements are intended to minimize the infiltration of water into the landfill and maintain the integrity of the cover during the post-closure care period by minimizing cover erosion. Minimum requirements for a final landfill cover are included; however, states with USEPA-approved programs may approve alternate cover designs. Post-closure care must be conducted for 30 years; however, states with USEPA-approved programs have the authority to lengthen or shorten the post-closure period.
State				
Virginia Waste Management Act and Solid Waste Management Regulation	9 VAC 20-81-160 (D)(2)(a), (c), and (f) and (D)(3)	Relevant and Appropriate for Alternative 3	These regulations describe the final cover for a solid waste disposal facility.	These requirements would be relevant and appropriate for site closure and post-closure care under Alternative 3, which would involve consolidating and covering contaminated soil with a vegetative soil cover, requiring post-construction periodic O&M and LUC inspections.

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SUMMARY OF FEDERAL AND STATE ARARs
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Requirement	Citation	Status	Synopsis of Requirement	Compliance Action
Virginia Hazardous Waste Determination	9 VAC 20-60-262 (refer to Federal regulation above)	Applicable to Alternatives 2 and 3	Defines method to determine if a solid waste is a hazardous waste.	Pre-construction TCLP samples will be collected for waste characterization to determine appropriate lead treatment prior to covering on-site (Alternative 3) or off-site transportation and disposal (Alternative 2). The on-site lead leachability treatment component (if needed) would stabilize lead in soils and render the material nonhazardous by characteristic, and, hence, allow for placement on-site under a soil cover (Alternative 3) or nonhazardous off-site transportation and disposal. TCLP samples would be collected after treatment to confirm the nonhazardous characteristic for lead has been achieved.
Virginia Erosion and Sediment Control Act Regulations	9 VAC 25-840-10 through -65, and -80	Applicable to Alternatives 2 and 3	Establishes requirements for erosion control to protect of the surface water of the state.	An E&S control plan will be implemented and adhered to during all construction activities under either of Alternatives 2 or 3.
Virginia General VPDES Permit for Discharge of Stormwater from Construction Activities	9 VAC 25-880	Applicable to Alternatives 2 and 3	Regulates quality of point-source stormwater discharges from small and large construction site.	Point source stormwater discharges from the site activities would meet the substantive requirements of this general permit.

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SUMMARY OF FEDERAL AND STATE ARARs
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Requirement	Citation	Status	Synopsis of Requirement	Compliance Action
Virginia Standards of Performance for Visible Emission and Fugitive Dust	9 VAC 5-50-90	Applicable to Alternatives 2 and 3	Establishes standards to minimize or prevent fugitive dusts from stationary sources, including the construction of the stationary sources or any other building, structure, facility, or installation.	If sustained visible dust emissions are observed during the implementation of Alternatives 2 or 3, then NASA will control these releases by reducing dust generation operations and/or hydrating the materials. Reasonable precautions (best management practices) will be taken to prevent particulate matter from becoming airborne during construction activities. These will be detailed in the Remedial Design or Remedial Action Work Plan, such as the following: Application of water to roads, materials, and stockpiles; covering open-bodied vehicles that are transporting materials or soil likely to create dust; and maintenance of roadways including the removal of soil that has been tracked out by equipment.

Notes:
ARAR – Applicable or Relevant and Appropriate Requirement
CFR – Code of Federal Regulations
IEUBK - Integrated Exposure Uptake Biokinetic [Model]
LOAEL - Lowest observed adverse effects level
LOEC – Lowest observed effect concentration
µg/dL – Micrograms per deciliter
mg/kg – Milligrams per kilogram
O&M – Operation and maintenance
RCRA – Resource Conservation and Recovery Act
USACE – United State Army Corps of Engineers
USEPA – United States Environmental Protection Agency
USFWS – United States Fish and Wildlife Service
PRG – Preliminary Remediation Goal
SSL – Soil Screening Level
TBC – To be considered
VAC – Virginia Administrative Code
VDEQ – Virginia Department of Environmental Quality
NASA – National Aeronautics and Space Administration
LUC – Land use control
NOAA – National Oceanic and Atmospheric Administration
TCLP – Toxicity Characteristic Leaching Procedure
PAH – Polycyclic aromatic hydrocarbon

1. Seven Target PAHs: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

TABLE 2-8
SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA PAGE 1 OF 11

NCP Criterion	Alternative 1 No Action	Alternative 2 Excavation and Off-Site Disposal	Alternative 3 Excavation, On-Site Consolidation, Soil Cover, O&M, and LUCs
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT			
Protection of Human Health and the Environment	Does not meet the RAOs. No reduction of identified unacceptable risks and no protection of human health and the environment.	Removing the contaminated soil and sediment meets the RAOs and avoids future actions or controls for the protection of human health and the environment.	Meets the RAOs for the protection of human health and the environment by preventing exposure to contaminated soil and sediment. The soil cover would be a barrier to contamination for industrial workers and ecological receptors; O&M would monitor and maintain the cover integrity. LUCs would prevent residential development (and, hence, residential exposure) and control intrusive activities.
COMPLIANCE WITH ARARs			
Chemical-Specific ARARs	Would not comply.	Would comply with ARARs.	Would comply with ARARs.
Location-Specific ARARs	Not applicable.	Would comply with ARARs.	Would comply with ARARs.
Action-Specific ARARs	Not applicable.	Would comply with ARARs.	Would comply with ARARs.

TABLE 2-8
SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES
SKEET RANGE MRS - FUDS PROJECT 9
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NCP Criterion	Alternative 1 No Action	Alternative 2 Excavation and Off-Site Disposal	Alternative 3 Excavation, On-Site Consolidation, Soil Cover, O&M, and LUCs
LONG-TERM EFFECTIVENESS AND PERMANENCE			
Magnitude of Residual Risk	Existing risks would remain.	Risks at the site would be mitigated by the excavation and disposal alternative. No residual risk would remain.	The soil cover with O&M would prevent industrial worker and ecological receptor exposure to the consolidated soil and sediment contamination causing the unacceptable risks. Implementation and enforcement of LUCs would limit future residential land use (and, hence, residential exposure) and intrusive activities. However, the residual risk would remain unchanged; exposure for industrial workers and ecological receptors would reoccur if the cover integrity is compromised, or potentially occur for residents or other human receptors if the site is developed for nonindustrial use.
Adequacy and Reliability of Controls	Not applicable. No long-term controls implemented.	Not applicable. No long-term controls implemented.	The federal facility has controlled access. LUCs are adequate and reliable when implemented and enforced. The long-term O&M will check and maintain the soil cover (barrier) integrity. Less reliability—and slightly more risk for workers—is anticipated for Alternative 3 than for Alternative 2 because of these long-term post-construction controls and efforts.

TABLE 2-8
SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES
SKEET RANGE MRS - FUDS PROJECT 9
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NCP Criterion	Alternative 1 No Action	Alternative 2 Excavation and Off-Site Disposal	Alternative 3 Excavation, On-Site Consolidation, Soil Cover, O&M, and LUCs
Need for Five-Year Review	No, because it is a "no-action" alternative; however, it is recognized that Five-Year Reviews are required under CERCLA if a site has not achieved UU/UE status.	No.	Yes.
Need for Long-Term Management	Not applicable.	No.	Long-term O&M and LUCs must be performed and maintained for protectiveness. LUC and soil cover inspections must be performed periodically. The soil cover integrity (e.g., erosion or animal burrows) must be maintained periodically. If property ownership is transferred with contamination remaining in place, then Environmental Land Use Restrictions (ELURs) would be recorded.

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SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA PAGE 4 OF 11

NCP Criterion	Alternative 1 No Action	Alternative 2 Excavation and Off-Site Disposal	Alternative 3 Excavation, On-Site Consolidation, Soil Cover, O&M, and LUCs
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT			
Treatment Process Used	No treatment would be employed under the no-action alternative.	While all contaminated media would be disposed of off-site, on-site chemical stabilization treatment of lead in the soil/sediment matrix would be performed to render any hazardous materials to nonhazardous prior to off-site transportation and disposal (if needed; depending on waste characterization results).	On-site chemical stabilization treatment of lead in the soil/sediment matrix would be performed to render any hazardous materials to nonhazardous prior to covering with a soil cover (both excavated soils to be consolidated and in situ soils to be covered) (if needed; depending on waste characterization results). The soil cover would be constructed and maintained on-site.
Amount Destroyed or Treated	No treatment would be employed under the no-action alternative.	Assuming 25% (estimated 2,200 tons) of excavated soil/sediment would be treated on-site to stabilize lead leachability prior to off-site disposal as nonhazardous waste (depending on waste characterization results).	Assuming 25% (estimated 2,200 tons) of in situ or excavated-to-be-consolidated soil/sediment would be treated on-site to stabilize lead leachability prior to covering (depending on waste characterization results). The soil cover would be constructed and maintained on-site.

TABLE 2-8
SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES
SKEET RANGE MRS - FUDS PROJECT 9
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NCP Criterion	Alternative 1 No Action	Alternative 2 Excavation and Off-Site Disposal	Alternative 3 Excavation, On-Site Consolidation, Soil Cover, O&M, and LUCs
Reduction of Toxicity, Mobility, or Volume Through Treatment	No treatment would be employed under the no-action alternative.	An assumed 2,200 tons of soil and sediment would be treated on-site to reduce lead leachability (pending waste characterization testing, which mimics more acidic landfill conditions). This will allow for nonhazardous off-site transportation and disposal of all materials.	An assumed 2,200 tons of soil and sediment would be treated on-site to reduce lead leachability (pending waste characterization testing, which mimics more acidic landfill conditions). This will allow for placing/covering nonhazardous in situ and consolidated soils on-site. Also, mobility would be reduced by the consolidation of the contaminated media under the 2-foot soil cover. Also, incidental compaction during consolidation may reduce the overall volume of contaminated media.
SHORT-TERM EFFECTIVENESS			
Community Protection	No additional risk to community because no actions are taken.	Some short-term risk to community is expected due to transportation/hauling of equipment, excavated materials for disposal (8,830 tons), and imported backfill (8,830 tons). Risks would be minimized through engineering controls, traffic control planning and haul routes, and use of experienced firms and personnel. More long-haul traffic is anticipated for Alternative 2 than for Alternative 3 due to the off-site disposal of excavated waste.	Some short-term risk to community is expected due to transportation/hauling of equipment and imported backfill (15,100 tons). Risks would be minimized through engineering controls, traffic control planning and haul routes, and use of experienced firms and personnel. More backfill will be imported to the site for Alternative 3 due to the soil cover construction; however, the backfill transportation distances are shorter than those for Alternative 2's off-site waste disposal.

TABLE 2-8
SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES
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NCP Criterion	Alternative 1 No Action	Alternative 2 Excavation and Off-Site Disposal	Alternative 3 Excavation, On-Site Consolidation, Soil Cover, O&M, and LUCs
Worker Protection	No risk to workers because no actions are taken.	No significant risk to workers is anticipated if proper PPE and typical safe work practices are used during excavation, backfilling, restoration, and transportation and disposal activities.	No significant risk to workers anticipated if proper PPE and typical safe work practices are used during excavation, backfilling, consolidation, soil cover installation, and restoration activities. More risk to site workers could be anticipated for Alternative 3 than for Alternative 2 because of the long-term post-construction controls and efforts (i.e., LUC/soil cover inspections and O&M of the soil cover).
Environmental Impacts	Additional adverse impact to the environment would be expected because no action is taken to address the ecological risks.	Best management practices and other engineering controls would minimize environmental impacts during excavation, backfilling, and restoration activities. Erosion and sediment (E&S) control measures would be used to prevent damage to the environment from soil/sediment runoff.	Best management practices and other engineering controls would minimize environmental impacts during excavation, backfilling, restoration, consolidation, and soil cover construction activities, as well as during establishment of vegetation on the soil cover. E&S control measures would be used to prevent damage to the environment from soil/sediment runoff.

TABLE 2-8
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NCP Criterion	Alternative 1 No Action	Alternative 2 Excavation and Off-Site Disposal	Alternative 3 Excavation, On-Site Consolidation, Soil Cover, O&M, and LUCs
Time until Remedial Action is Complete	Not Applicable.	3 months to complete on-site construction and off-site transportation and disposal. Additional/typical post-construction monitoring of revegetation and subsequently removing the E&S controls. Would attain unrestricted use and unlimited exposure (UU/UE).	3 months to complete on-site construction. Additional/typical post-construction monitoring of revegetation and subsequently removing the E&S controls. Long-term O&M and LUCs in perpetuity; would not attain UU/UE.
IMPLEMENTABILITY			
Ability to Construct and Operate	Not applicable.	Other than coordination with the airfield, no major difficulties are anticipated based on previous remedial actions at the facility. Excavation, backfilling, restoration, and off-site disposal are readily implementable practices. Chemical stabilization of lead is also an established, readily implementable technology.	Other than coordination with the airfield, no major difficulties are anticipated based on previous remedial actions at the facility. Excavation, consolidation, backfilling, restoration, and construction of a soil cover are readily implementable technologies. However, the future mission of the NOAA antennae facility and the NASA airfield (e.g., expansions) could be impacted by the 2-acre covered soil area to be established in proximity to them.
Reliability of the Technology	Not applicable.	Reliable.	Reliable. Future controls and actions are reliable albeit in perpetuity.

TABLE 2-8
SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES
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NCP Criterion	Alternative 1 No Action	Alternative 2 Excavation and Off-Site Disposal	Alternative 3 Excavation, On-Site Consolidation, Soil Cover, O&M, and LUCs
Ease of Doing More Action if Needed	Additional actions would be easily implemented if required.	Additional actions would be easily implemented if required (e.g., expand excavation areas).	Additional actions would be easily implemented if required (e.g., expand excavation areas or change consolidation/cover area configuration).
Ability to Monitor Effectiveness	No monitoring would occur under the no-action alternative.	Not applicable other than confirmation sampling prior to completion.	Confirmation sampling would occur prior to completion of construction. Long-term O&M and inspections would be required to confirm and maintain cover integrity and LUCs; assuming major soil cover maintenance every 5 years. Future monitoring is straight-forward albeit in perpetuity.

TABLE 2-8
SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES
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NCP Criterion	Alternative 1 No Action	Alternative 2 Excavation and Off-Site Disposal	Alternative 3 Excavation, On-Site Consolidation, Soil Cover, O&M, and LUCs
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable.	Would comply with all ARARs. Coordination with federal, state, and base agencies would be required for working near the coast, near endangered or threatened species, wetlands, and cultural resources, as well as for disturbing/constructing a sizable area (4.4 acres under Alternative 2); however, no permits would be required because the CERCLA remedial action would occur on-site. These processes have been performed for other remedial actions at the facility. Typical coordination for transportation and off-site disposal of excavated materials. On-site treatment to chemically stabilize lead in soils (if needed) could be performed under USEPA's AOC Policy (see Table 4-4).	Would comply with all ARARs. Coordination with federal, state, and base agencies would be required working near the coast, near endangered or threatened species, wetlands, and cultural resources, as well as for disturbing/constructing a sizable area (4.5 acres under Alternative 3); however, no permits would be required because the CERCLA remedial action would occur on-site. These processes have been performed for other remedial actions at the facility. On-site treatment to chemically stabilize lead in soils (if needed) could be performed under USEPA's AOC Policy (see Table 4-4). LUCs should not be difficult to implement and enforce. Would require periodic coordination with airfield and potentially NOAA antenna facility for inspections and O&M.
Availability of Treatment, Storage Capacities, and Disposal Services	Not applicable.	Readily available.	Readily available.

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NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA PAGE 10 OF 11

NCP Criterion	Alternative 1 No Action	Alternative 2 Excavation and Off-Site Disposal	Alternative 3 Excavation, On-Site Consolidation, Soil Cover, O&M, and LUCs
Availability of Equipment, Specialists, and Materials	Not applicable.	Ample availability of equipment and personnel to perform excavation, backfilling, and off-site transportation and disposal. Chemical stabilization reagent mixing for lead would require coordination with a specialized subcontractor/vendor.	Ample availability of equipment and personnel to perform excavation and consolidation, backfilling, and construction of the soil cover. Chemical stabilization reagent mixing for lead would require coordination with a specialized subcontractor/vendor. Materials and skills also are available for long-term O&M and LUC implementation and enforcement.
Availability of Technology	Not applicable.	Available. Excavation, chemical stabilization, and off-site disposal are commonly used technologies.	Available. Excavation, consolidation, and soil covers are commonly used technologies.
COST			
Capital Cost	$0	$2,386,000	$1,568,000
O&M Cost	$0	$0	O&M (PV $171K over 100 years) ▪ $500 – Annually ▪ $8K – Every 5 years

TABLE 2-8
SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES
SKEET RANGE MRS - FUDS PROJECT 9
NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA PAGE 11 OF 11

NCP Criterion	Alternative 1 No Action	Alternative 2 Excavation and Off-Site Disposal	Alternative 3 Excavation, On-Site Consolidation, Soil Cover, O&M, and LUCs
Other Periodic Costs (Years 1 to 30)	$0	$0	LUC Inspections/Reporting (PV $231K over 100 years) ▪ $11K – Quarterly Years 1 and 2 ▪ $2K – Annually thereafter 5-Year Reviews (PV $245K over 100 years) ▪ –$15K – Every 5 years
Total Present Value (PV)[(1)]	$0	$2,386,000	2,216,000 (over 100 years)

Notes:
NCP – National Contingency Plan
RAO – Remedial Action Objective
PPE – Personal protective equipment
USEPA – United States Environmental Protection Agency
O&M – Operation and maintenance
COC – Chemical of Concern
NOAA – National Oceanic and Atmospheric Administration
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
LUC – Land use control
PRG – Preliminary Remediation Goal

1. Present Value (PV) is the present worth cost for Alternative 3 based on an annual real discount rate of 0.4 percent over 100 years in this case (OMB, 2019). For comparison, if estimated over only 30 years, the PV total would be $1,801,000. Estimating over 100 years provides more accurate information to stakeholders per USEPA (2000).

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Figures

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SITE LOCATION MAP
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

FILE	SCALE AS NOTED
FIGURE NO. 2-1	REV DATE 8/16/16

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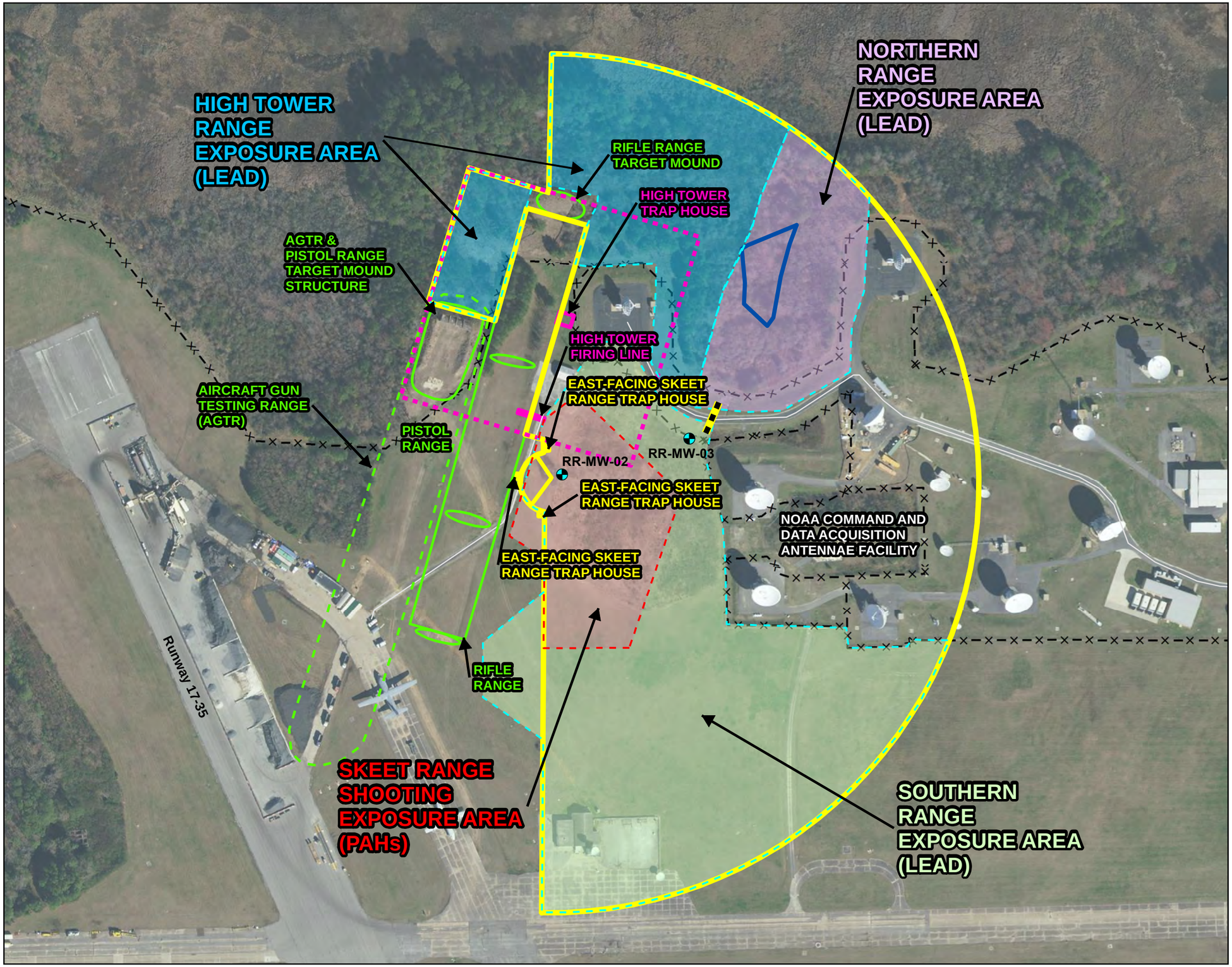
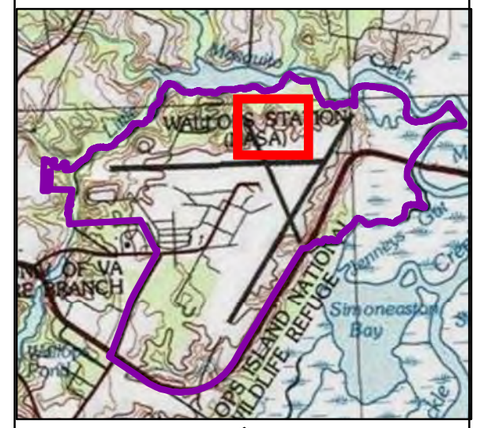


Legend

- Fenceline
- Lead Exposure Area
- PAH Exposure Area
- Palustrine Forested Wetland (2018)
- High Tower Range
- Approximate AGTR Boundary
- Other MBFR Features
- High Tower Range Exposure Area
- Northern Range Exposure Area
- Skeet Range Shooting Exposure Area (PAHs)
- Southern Range Exposure Area
- Skeet Range MRS
- Installation Boundary
- Culvert
- 2007 Site Investigation Temporary Monitoring Well



N

0 100 200 400 Feet

SITE LAYOUT
SKEET RANGE MRS
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

2-2	11/9/2020

Aerial Imagery 2013 ESRI map service
USA Topo Map 2013 ESRI map service

Coordinate System: North American Datum, 1983 VA South, Meters

NOR: G:\GIS_files\NASA WI\MXD\MBFR\SkeetRange\MBFR_exposure110920.mxd MMC

RIFLE RANGE TARGET MOUND

AGTR AND PISTOL RANGE

HIGH TOWER RANGE

HIGH TOWER TRAP HOUSE

HIGH TOWER RANGE FIRING LINE

SR-SS-241 SR-SS-242 SR-SS-243 SR-SS-244 SR-SS-245 SR-SS-246 SR-SS-247 SR-SS-248 SR-SS-249 SR-SS-250 SR-SS-251

SR-SS-332 SR-SS-319 SR-SS-318 SR-SS-333 SR-SS-414 SR-SS-320 SR-SS-321 SR-SS-413 SR-SS-253 SR-SS-256N SR-SS-322 SR-SS-255 SR-SS-039 SR-SS-412 SR-SS-252 SR-SS-254 SR-SS-256 SR-SS-256E SR-SS-323 SR-SS-411 SR-SS-407 SR-SS-334 SR-SS-324 SR-SS-410 SR-SS-408 SR-SS-203 SR-SS-038 SR-SS-006 SR-SS-108 SR-SS-208 SR-SS-210 SR-SS-409 SR-SS-304 SR-SS-209 SR-SS-107 SR-SS-211 SR-SS-416 SR-SS-415 SR-SS-207 SR-SS-202 SR-SS-417 SR-SS-037 SR-SS-303 SR-SS-420 SR-SS-100 SR-SS-103 SR-SS-418 SR-SS-419 SR-SS-101 SR-SS-005 SR-SS-206 SR-SS-212 SR-SS-104 SR-SS-421 SR-SS-305 SR-SS-302 SR-SS-205 SR-SS-105 SR-SS-102 SR-SS-213 SR-SS-301 SR-SS-204 SR-SS-306 SR-SS-215 SR-SS-106 SR-SS-201 SR-SS-307 SR-SS-012 SR-SS-214

SR-SS-004 SR-SS-035 SR-SS-264 SR-SS-003 SR-SS-034 SR-SS-002 SR-SS-257 SR-SS-265 SR-SS-033 SR-SS-011 SR-SS-036 SR-SS-010 SR-SS-260 SR-SS-001 SR-SS-008 SR-SS-009 SR-SS-226 SR-SS-007 SR-SS-258 SR-SS-225 SR-SS-013 SR-SS-014 SR-SS-261 SR-SS-019 SR-SS-274

Notes:

The PRGs for soil in this High Tower Range Exposure area are:

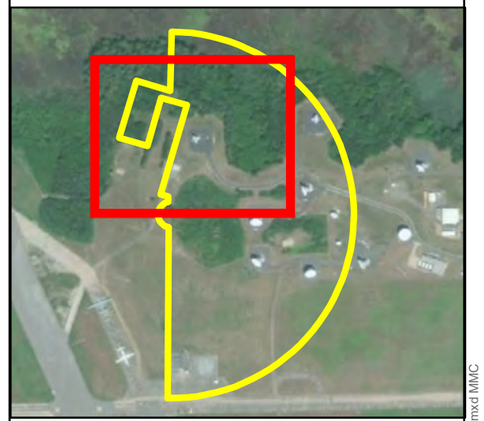
- Human Health (HH) Lead average-PRG = 200 mg/kg
- Ecological (Eco) Lead average-PRG = 240 mg/kg
- Eco Lead not-to-exceed-PRG = 750 mg/kg
- Eco Lead Shot (LS) not-to-exceed-PRG = 100 LS/ft^2

HH: The average lead in surface and subsurface soil in this exposure area are below the HH average PRG. Individual exceedances of the HH average-PRG of 200 mg/kg are indicated on this figure for comprehensive presentation and for evaluation of potential hot spots.

Eco: The average lead in surface / shallow subsurface soil in this exposure area are below the Eco average-PRG, and all individual concentrations

Legend

- SI Sediment Sample
- SI Surface Soil Sample
- RI Sediment Samples
- RI Surface and Subsurface Soil Sample
- RI Surface Soil Sample
- Palustrine Forested Wetland (2018)
- Culvert
- Fence Line
- 2010 LIDAR Contours (feet msl)
- Exceeds 100 LS/Square Foot
- High Tower Range Exposure Area
- Structure Existing Area
- Rifle Range Target Mound
- Approximate AGTR Boundary
- High Tower Range
- Skeet Range MRS
- Paved Surfaces
- SR-SS-038 Lead greater than 200 mg/kg



N

0 30 60 120 Feet

SAMPLE LOCATIONS AND EXCEEDANCES
HIGH TOWER RANGE EXPOSURE AREA
SKEET RANGE MRS
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

NASA	2-3	11/12/2020

Aerial Imagery 2013 ESRI map service

Coordinate System: North American Datum, 1983 VA South, Meters

NOR: G:\GIS_files\NASA WI\MXD\MBFR\SkeetRange\SR_pro_hightower_LSLocation111220.mxd MMC

Notes:

The PRGs for soil in this Southern Range Exposure Area are:

- Human Health (HH) Lead average-PRG = 200 mg/kg
- Ecological (Eco) Lead average-PRG = 240 mg/kg
- Eco Lead not-to-exceed-PRG = 750 mg/kg
- Eco Lead Shot (LS) not-to-exceed-PRG = 100 LS/square foot

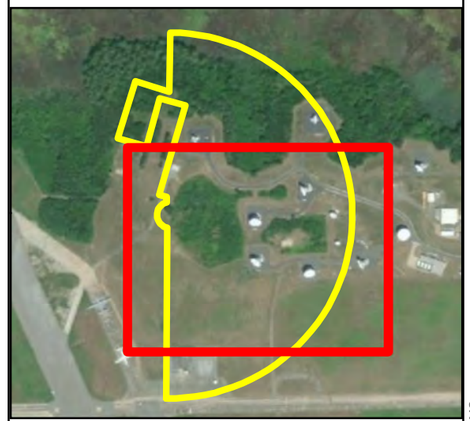
HH: The average lead concentration in surface soil is above the HH average PRG, but the average lead in subsurface soil is below the PRG. Lead models indicate (i) unacceptable blood lead levels in children from surface but not subsurface soil and (ii) no unacceptable blood lead levels for the fetus of a pregnant worker in surface or subsurface soil. Individual exceedances of the HH average PRG of 200 mg/kg are indicated on this figure for comprehensive presentation and for evaluation of potential hot spots.

Eco: The average lead concentration in surface/shallow subsurface soil in this exposure area is below the Eco average PRG, but several individual concentrations are above the Eco not-to-exceed PRG for soil. Also, there are exceedances of the Eco LS not-to-exceed PRG in this exposure area.

NOAA COMMAND AND DATA ACQUISTION ANTENNAE FACILITY

Legend

- Si Sediment Sample
- SI Surface Soil Sample
- RI Sediment Samples
- RI Surface and Subsurface Soil Sample
- RI Surface Soil Sample
- Total risk from PAH COCs > 1 x 10^{-4}
- Exceeds 100 LS/Square Foot
- Culvert
- 2010 LIDAR Contours (feet msl)
- Fence Line
- Southern Range Exposure Area
- Structure Existing Area
- Skeet Range MRS
- Paved Surfaces
- SR-SS-038 Lead greater than 200 mg/kg



N

0 50 100 200 Feet

SAMPLE LOCATIONS AND EXCEEDANCES
SOUTHERN RANGE EXPOSURE AREA
SKEET RANGE MRS
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

2-4	3/17/2021

Aerial Imagery 2013 ESRI map service

Coordinate System: North American Datum, 1983 VA South, Meters

NOR: G:\GIS_files\NASA WI\MXD\MBFR\SkeetRange\SR_southern_LSLocation_111220.mxd MMC

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Legend

- SI Sediment Sample
- SI Surface Soil Sample
- RI Sediment Samples
- RI Surface and Subsurface Soil Sample
- RI Surface Soil Sample
- Culvert
- High Tower Range Exposure
- Northern Range Exposure
- Exceeds 100 LS/Square Foot
- 2010 LIDAR Contours (feet msl)
- Fence Line
- Palustrine Forested Wetland (2018)
- Skeet Range MRS
- Paved Surfaces
- SR-SS-038 Lead greater than 200 mg/kg

N

SR-SS-412
SR-SS-039
SR-SS-411
SR-SS-323
SR-SS-334
SR-SS-324
SR-SS-410
SR-SS-006
SR-SS-409
SR-SS-038
SR-SS-208
SR-SS-103
SR-SS-210
SR-SS-203
SR-SS-209
SR-SS-415
SR-SS-416
SR-SS-304
SR-SS-417
SR-SS-107
SR-SS-207
SR-SS-211
SR-SS-303
SR-SS-420
SR-SS-418
SR-SS-419
SR-SS-206
SR-SS-103
SR-SS-202
SR-SS-101
SR-SS-037
SR-SS-212
SR-SS-104
SR-SS-105
SR-SS-100
SR-SS-205
SR-SS-102
SR-SS-305
SR-SS-421
SR-SS-302
SR-SS-213
SR-SS-201
SR-SS-106
SR-SS-204
SR-SS-214
SR-SS-306
SR-SS-301
SR-SS-215
SR-SS-307
SR-SS-012

Notes:
- Human Health (HH) Lead average-PRG (soil) = 200 mg/kg
- Ecological (Eco) Lead average-PRG (soil) = 240 mg/kg
- Eco Lead not-to-exceed-PRG (soil) = 750 mg/kg
- Eco Lead not-to-exceed-PRG (sediment) = 530 mg/kg
- Eco Lead Shot (LS) not-to-exceed-PRG (soil) = 100 LS/Square Foot

HH: (The dry sediment [i.e., RI Sediment Samples] was evaluated as soil in the HH risk assessment). The average lead concentrations in surface and subsurface soils in this exposure area are above the HH average-PRG. Lead models indicate (i) unacceptable blood lead levels in children from surface and subsurface soil and (ii) unacceptable blood lead levels in the fetus of a pregnant worker from surface soil. Individual exceedances of the HH average-PRG of 200 mg/kg are indicated on this figure for comprehensive presentation and for evaluation of potential hot spots.

Eco: The average lead concentration in surface / shallow subsurface soil and sediment in this exposure area is above the Eco average-PRG, and many individual concentrations are above the Eco not-to-exceed-PRGs for soil and sediment. Also, there are exceedances of the Eco LS not-to-exceed-PRG in this exposure area.

Base Map:
Aerial Imagery 2013 ESRI map service

SAMPLE LOCATIONS AND EXCEEDANCES
NORTHERN RANGE EXPOSURE AREA
SKEET RANGE MRS
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

0 30 60 Feet

2-5

Prepared By: TETRA TECH

Date: 11/12/2020

NOR: G:\GIS_files\NASA WIMXD\MBFR\SkeetRange\SkeetRange_Northern_Location111220.mxd MMC

Legend

- SI Sediment Sample
- SI Surface Soil Sample
- RI Sediment Samples
- RI Surface and Subsurface Soil Sample
- RI Surface Soil Sample
- Total risk from PAH COCs > 1 x 10^{-4}
- Fence Line
- 2010 LIDAR Contours (feet msl)
- Culvert
- Palustrine Forested Wetland (2018)
- Skeet Range Shooting Exposure Area (PAHs)
- Exceeds 100 LS/Square Foot
- Skeet Range MRS
- Structure Existing Area
- Paved Surfaces
- SR-SS-038 Lead greater than 200 mg/kg

N

Notes:
This Skeet Range Shooting Exposure Area is a sub-exposure area of the Southern Range Exposure Area. In thus sub-area, PAHs contribute to unacceptable cancer human health risk for hypothetical residential receptors.

Human Health: The Human Health PRG for PAHs in soil in this sub-area is an individual not-to-exceed target cancer risk (TCR) of 1x10^-4. Calculated incremental lifetime cancer risks (ILCRs) in subsurface soil in this sub-exposre area are above the PRG as indicated on this figure.

Ecological: There are no unacceptable ecolofical risks from PAHs at the site.

Individual lead concentrations above 200 mg/kg are indicated on this figure for the respective locations associated with other exposure areas within view for comprehensive presentation.

NOAA COMMAND AND DATA ACQUISTION ANTENNAE FACILITY

Base Map:
Aerial Imagery 2013 ESRI map service

SAMPLE LOCATIONS AND EXCEEDANCES
SKEET RANGE SHOOTING EXPOSURE AREA
SKEET RANGE MRS
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

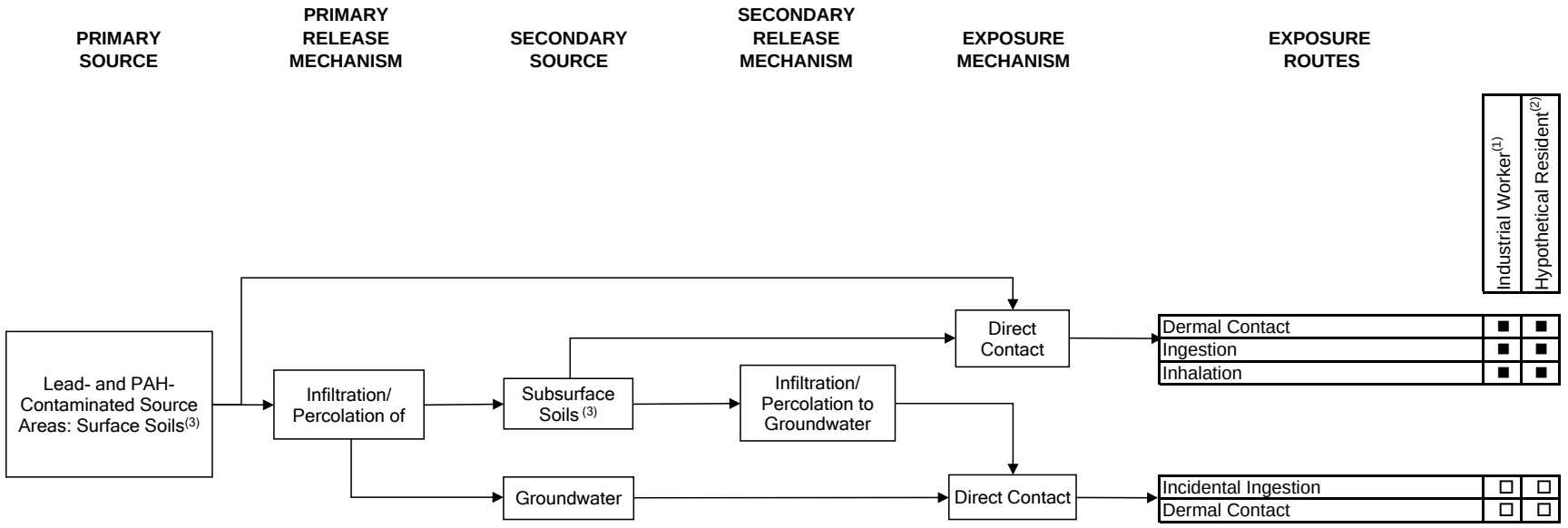
0 70 140 Feet

2-6

Prepared By: TETRA TECH

Date: 3/17/2021

NOR: G:\GIS_files\NASA WIMXD\MBFR\SkeetRange\SkeetRange_PAH_pro_111220.mxd KMB

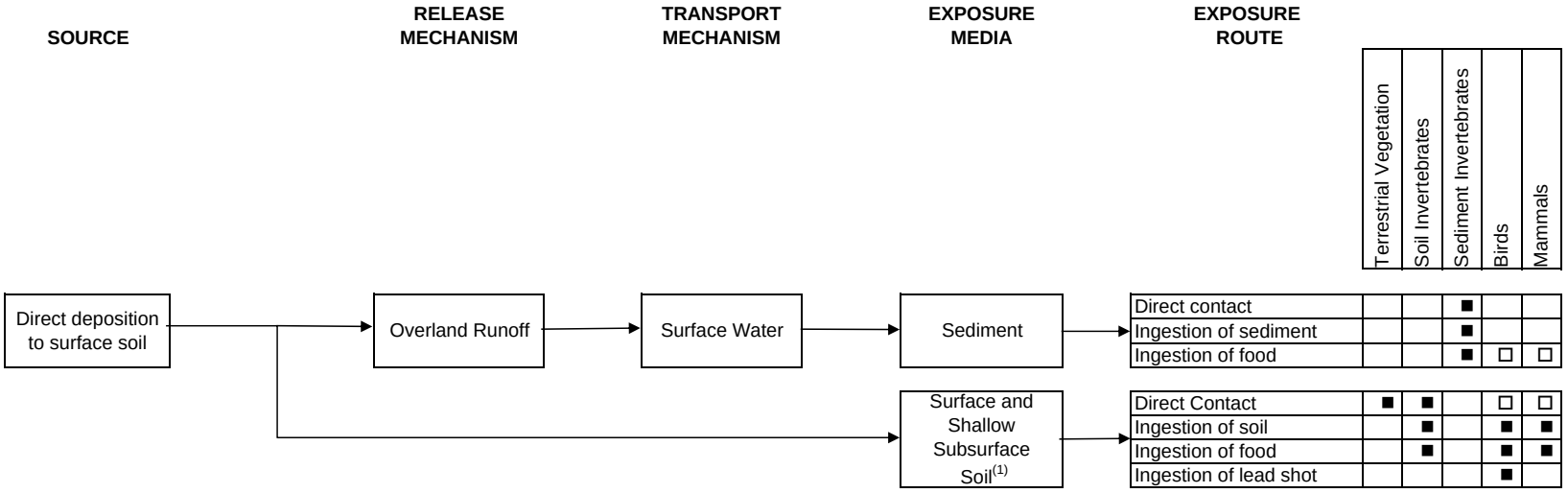


LEGEND

- ■ Exposure pathway that is quantitatively evaluated in the Human Health Risk Assessment.
- □ Represents an incomplete exposure pathway based on available contaminant concentration data.

1. Potential receptor under current or future land use
2. Potential (but unlikely) receptor under future land use. Evaluated for decision-making purposes.
3. In the Human Health Risk Evaluation, surface soil is defined as 0-6 inches and subsurface soil as 6-24 inches below ground surface.

FIGURE 2-7
HUMAN HEALTH CONCEPTUAL SITE MODEL
SKEET RANGE MRS
NASA WALLOPS FLIGHT FACILITY, VIRGINIA



Legend

■ = Complete Exposure Pathway

□ = Complete Exposure Pathway, but not evaluated because it is considered to be insignificant.

Blank space indicates incomplete exposure pathway or relatively insignificant, or not applicable, potential exposure.

1. In the screening-level Ecological Risk Assessment, surface soil is defined as 0-6 inches, shallow subsurface soil as 6-12 inches, and subsurface soil is 12-24 inches below ground surface.

FIGURE 2-8
ECOLOGICAL CONCEPTUAL SITE MODEL
SKEET RANGE MRS
NASA WALLOPS FLIGHT FACILITY, VIRGINIA

L1/LS 1

PAH 1

LS 3

PAH 3

NOAA COMMAND AND
DATA ACQUISITION
ANTENNAE FACILITY

PAH 2

L 2/LS2

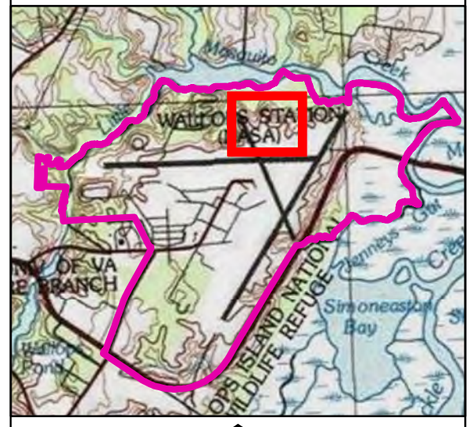
Runway 17-35

Legend

- Palustrine Forested Wetland (2018)
- Fenceline
- Areas for Excavation (0-1 Foot)
- Skeet Range MRS
- Culvert

Notes:

- All excavations will be conducted to 1 foot below ground surface. This depth would address all risk.
- All excavated PAH contaminated soil would be classified as non-hazardous.
- Approximately 70% of excavated lead- and lead shot- contaminated soil would be characterized as hazardous waste. The remaining 30% would be classified as non-hazardous waste.
- Hazardous and non-hazardous wastes would be transported off site to their respective appropriate disposal facilities.
- Excavated areas would be backfilled and restored to orignial physical site conditions to the extent practical.



N

0 100 200 400 Feet

FIGURE 2-9
ALTERNATIVE 2- EXCAVATION AND OFF-SITE DISPOSAL
SKEET RANGE MRS
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

3/17/2021

Aerial Imagery 2013 ESRI map service
USA Topo Map 2013 ESRI map service

Coordinate System: North American Datum, 1983 VA South, Meters

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APPENDIX A

LEAD MODELING RESULTS

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IEUBK MODELING RESULTS

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LEAD MODEL FOR WINDOWS Version 2.0

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate.

While IEUBK Model output is generally written with three digits to the right of the decimal point, the true precision of the output is strongly influenced by least precise input values.

==========

Model Version: 2.0 Build1
User Name: Tetra Tech
Date: 02/21/2024
Site Name: NASA Wallops Island
Operable Unit: Northern Range Area - Surface Soil
Run Mode: Site Risk Assessment

 # Soil/Dust Data
Average concentration of lead in surface soil at Northern Ange Area = 1,107 mg/kg.

==========

******** Air ********

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Month	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (µg Pb/m^3)
6-12	1.000	3.216	32.000	0.100
12-24	2.000	4.970	32.000	0.100
24-36	3.000	6.086	32.000	0.100
36-48	4.000	6.954	32.000	0.100
48-60	4.000	7.682	32.000	0.100
60-72	4.000	8.318	32.000	0.100
72-84	4.000	8.887	32.000	0.100

******** Diet ********

Month	Diet Intake(µg/day)
6-12	2.660
12-24	5.030
24-36	5.210
36-48	5.380
48-60	5.640
60-72	6.040
72-84	5.950

******** Drinking Water ********

Water Consumption:

Month	Water (L/day)
6-12	0.400
12-24	0.430
24-36	0.510
36-48	0.540
48-60	0.570
60-72	0.600
72-84	0.630

Drinking Water Concentration: 0.900 µg Pb/L

******** Soil & Dust ********

Multiple Source Analysis Used
Average multiple source concentration: 784.900 µg/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Month	Soil (µg Pb/g)	House Dust (µg Pb/g)
6-12	1107.000	784.900
12-24	1107.000	784.900
24-36	1107.000	784.900
36-48	1107.000	784.900
48-60	1107.000	784.900
60-72	1107.000	784.900
72-84	1107.000	784.900

******** Alternate Intake ********

Month	Alternate (µg Pb/day)
6-12	0.000
12-24	0.000
24-36	0.000
36-48	0.000
48-60	0.000
60-72	0.000
72-84	0.000

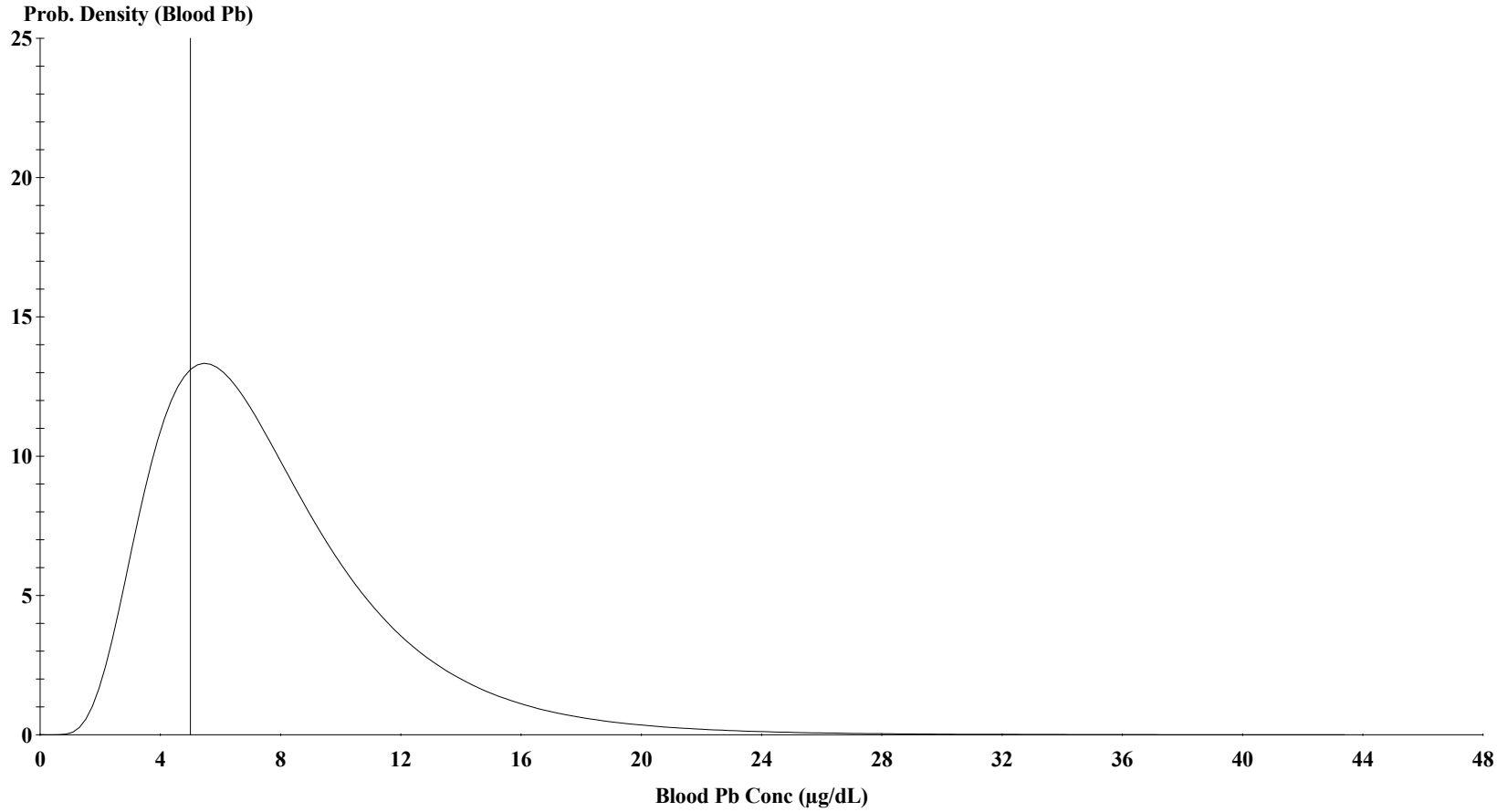
******** Maternal Contribution: Infant Model ********

Maternal Blood Concentration: 0.540 µg Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Month	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
6-12	0.034	1.050	0.000	0.142
12-24	0.057	2.036	0.000	0.157
24-36	0.075	2.261	0.000	0.199
36-48	0.093	2.392	0.000	0.216
48-60	0.102	2.530	0.000	0.230
60-72	0.111	2.787	0.000	0.249
72-84	0.118	2.754	0.000	0.262

Month	Soil+Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
6-12	18.941	20.167	10.4
12-24	21.232	23.482	9.9
24-36	16.224	18.760	7.4
36-48	15.627	18.327	6.4
48-60	16.769	19.632	6.3
60-72	13.384	16.531	5.4
72-84	14.200	17.335	4.9

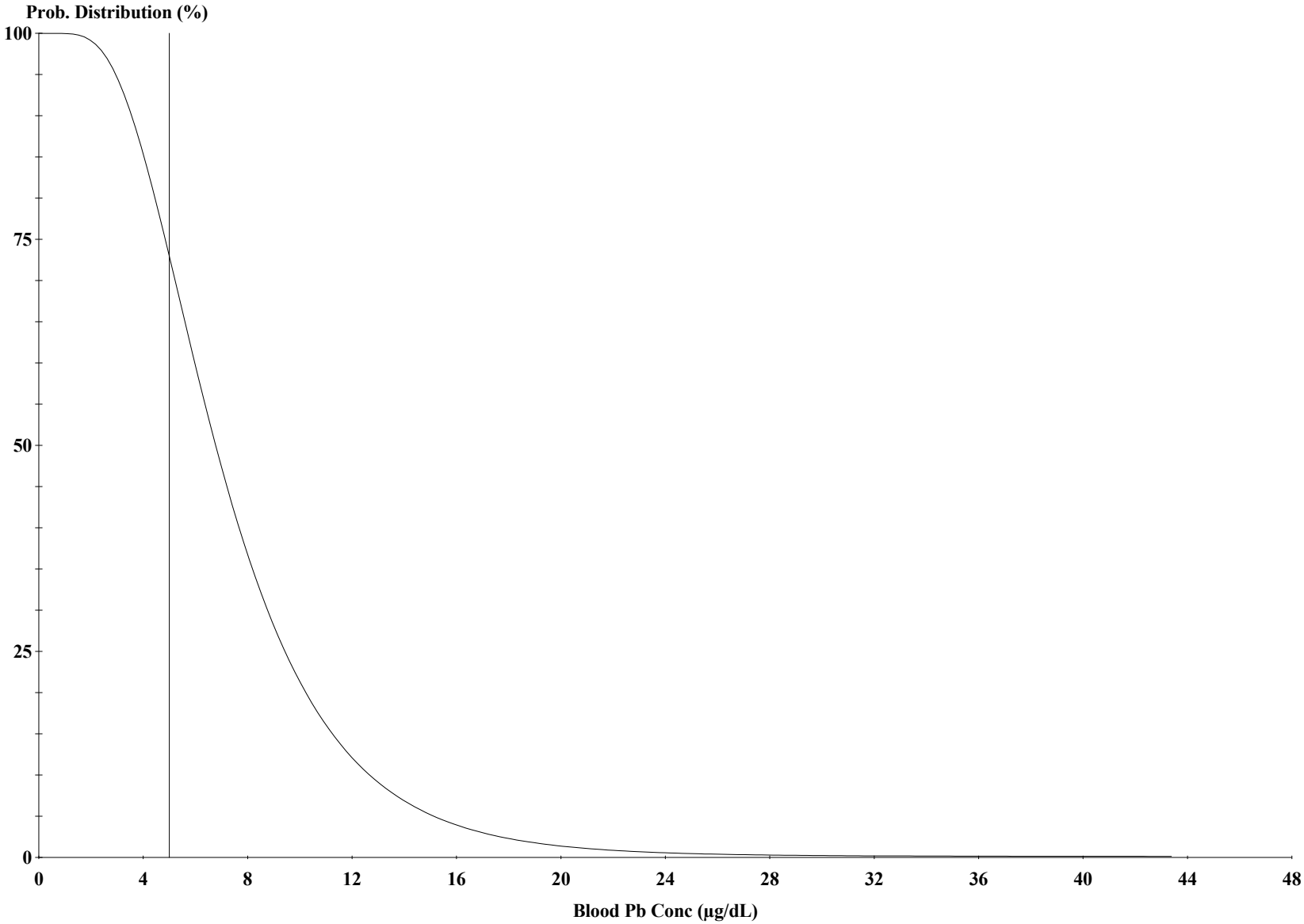


Cutoff = 5.000 µg/dl
Geo Mean = 7.097
GSD = 1.600
% Above = 77.193
% Below = 22.807

Age Range = 12 to 72 months

Run Mode = Site Risk Assessment
Comment = Northern Area - Surface Soil

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate.
While IEUBK Model output is generally written with three digits to the right of the decimal point, the true precision of the output is strongly influenced by least precise input values.



Cutoff = 5.000 µg/dl
Geo Mean = 7.097
GSD = 1.600
% Above = 77.193

Age Range = 12 to 72 months

Run Mode = Site Risk Assessment
Comment = Northern Area - Surface Soil

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate.
While IEUBK Model output is generally written with three digits to the right of the decimal point, the true precision of the output is strongly influenced by least precise input values.

LEAD MODEL FOR WINDOWS Version 2.0

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate.

While IEUBK Model output is generally written with three digits to the right of the decimal point, the true precision of the output is strongly influenced by least precise input values.

==========

Model Version: 2.0 Build1
User Name: Tetra Tech
Date: 02/21/2024
Site Name: NASA Wallops Island
Operable Unit: Northern Range Area - Subsurface Soil
Run Mode: Site Risk Assessment

 # Soil/Dust Data
Average concentration of lead in subsurface soil at Northern Range Area = 170 mg/kg.

==========

******** Air ********

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Month	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (µg Pb/m^3)
6-12	1.000	3.216	32.000	0.100
12-24	2.000	4.970	32.000	0.100
24-36	3.000	6.086	32.000	0.100
36-48	4.000	6.954	32.000	0.100
48-60	4.000	7.682	32.000	0.100
60-72	4.000	8.318	32.000	0.100
72-84	4.000	8.887	32.000	0.100

******** Diet ********

Month	Diet Intake(µg/day)
6-12	2.660
12-24	5.030
24-36	5.210
36-48	5.380
48-60	5.640
60-72	6.040
72-84	5.950

******** Drinking Water ********

Water Consumption:

Month	Water (L/day)
6-12	0.400
12-24	0.430
24-36	0.510
36-48	0.540
48-60	0.570
60-72	0.600
72-84	0.630

Drinking Water Concentration: 0.900 µg Pb/L

******** Soil & Dust ********

Multiple Source Analysis Used
Average multiple source concentration: 129.000 µg/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Month	Soil (µg Pb/g)	House Dust (µg Pb/g)
6-12	170.000	129.000
12-24	170.000	129.000
24-36	170.000	129.000
36-48	170.000	129.000
48-60	170.000	129.000
60-72	170.000	129.000
72-84	170.000	129.000

******** Alternate Intake ********

Month	Alternate (µg Pb/day)
6-12	0.000
12-24	0.000
24-36	0.000
36-48	0.000
48-60	0.000
60-72	0.000
72-84	0.000

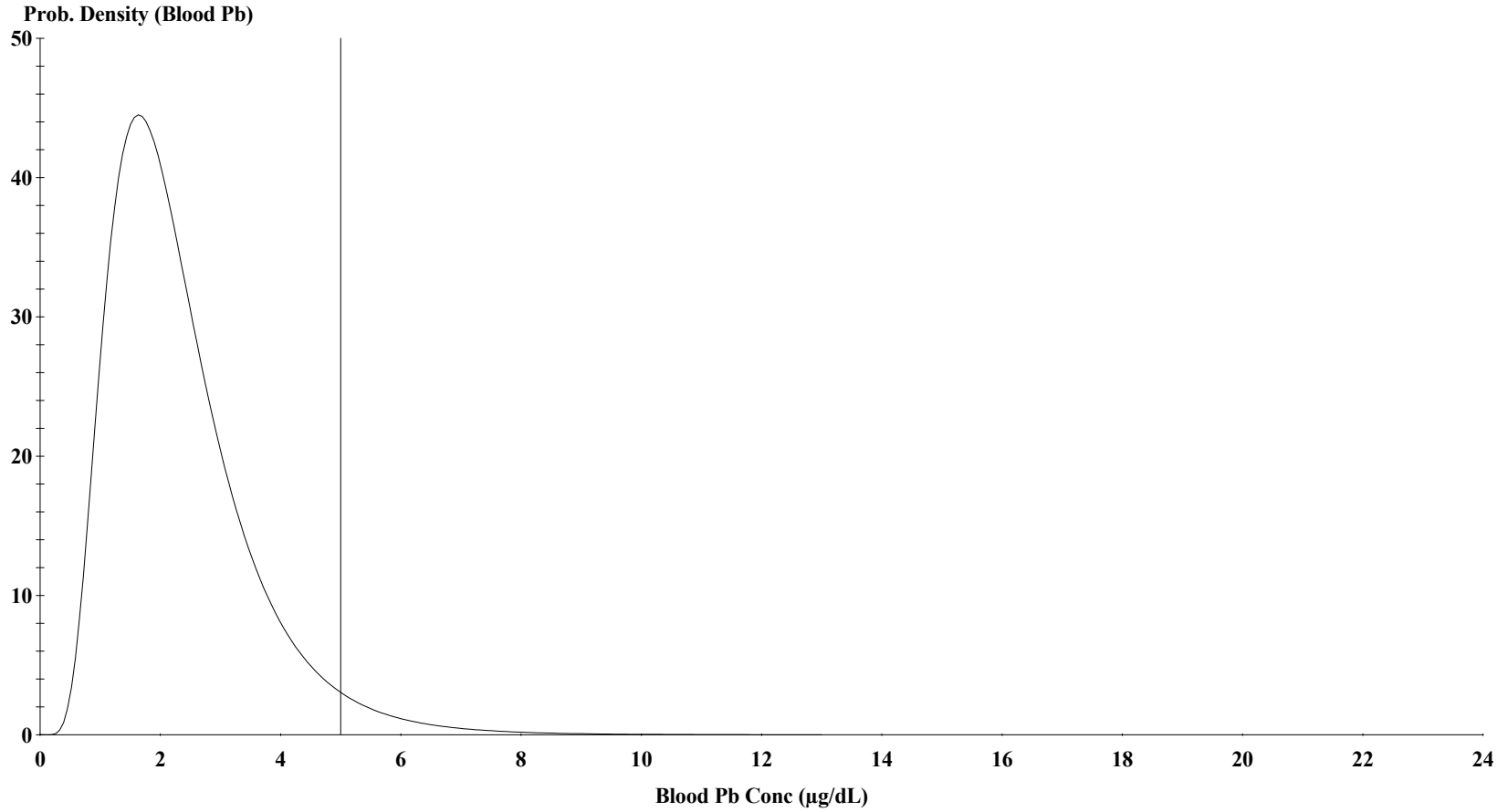
******** Maternal Contribution: Infant Model ********

Maternal Blood Concentration: 0.540 µg Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Month	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
6-12	0.034	1.256	0.000	0.170
12-24	0.057	2.376	0.000	0.183
24-36	0.075	2.500	0.000	0.220
36-48	0.093	2.598	0.000	0.235
48-60	0.102	2.731	0.000	0.248
60-72	0.111	2.941	0.000	0.263
72-84	0.118	2.903	0.000	0.277

Month	Soil+Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
6-12	3.593	5.053	2.7
12-24	3.929	6.545	2.7
24-36	2.844	5.639	2.2
36-48	2.691	5.616	2.0
48-60	2.871	5.953	1.9
60-72	2.240	5.556	1.8
72-84	2.374	5.671	1.6



Cutoff = 5.000 µg/dl
Geo Mean = 2.127
GSD = 1.600
% Above = 3.448
% Below = 96.552

Age Range = 12 to 72 months

Run Mode = Site Risk Assessment
Comment = Subsurface Soil

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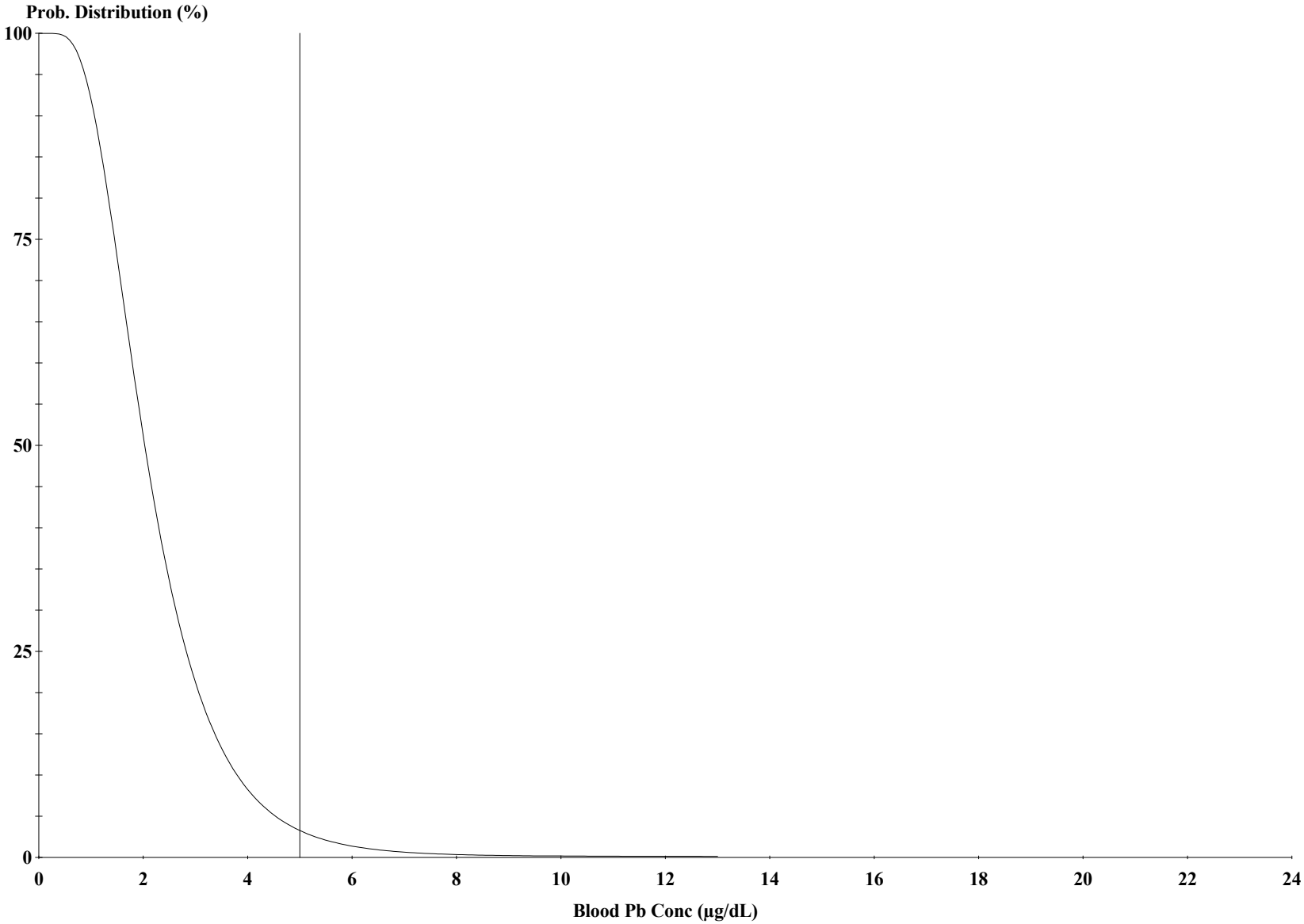

Cutoff = 5.000 µg/dl
Geo Mean = 2.127
GSD = 1.600
% Above = 3.448

Age Range = 12 to 72 months

Run Mode = Site Risk Assessment
Comment = Subsurface Soil

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LEAD MODEL FOR WINDOWS Version 2.0

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==========
Model Version: 2.0 Build1
User Name: Tetra Tech
Date: 02/21/2024
Site Name: NASA Wallops Island
Operable Unit: Southern Range Area - Surface Soil
Run Mode: Site Risk Assessment

 # Soil/Dust Data
Average concentration of lead in surface soil at Southern Range Area = 190 mg/kg.
==========

******** Air ********

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Month	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (µg Pb/m^3)
6-12	1.000	3.216	32.000	0.100
12-24	2.000	4.970	32.000	0.100
24-36	3.000	6.086	32.000	0.100
36-48	4.000	6.954	32.000	0.100
48-60	4.000	7.682	32.000	0.100
60-72	4.000	8.318	32.000	0.100
72-84	4.000	8.887	32.000	0.100

******** Diet ********

Month	Diet Intake(µg/day)
6-12	2.660
12-24	5.030
24-36	5.210
36-48	5.380
48-60	5.640
60-72	6.040
72-84	5.950

******** Drinking Water ********

Water Consumption:

Month	Water (L/day)
6-12	0.400
12-24	0.430
24-36	0.510
36-48	0.540
48-60	0.570
60-72	0.600
72-84	0.630

Drinking Water Concentration: 0.900 µg Pb/L

******** Soil & Dust ********

Multiple Source Analysis Used
Average multiple source concentration: 143.000 µg/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Month	Soil (µg Pb/g)	House Dust (µg Pb/g)
6-12	190.000	143.000
12-24	190.000	143.000
24-36	190.000	143.000
36-48	190.000	143.000
48-60	190.000	143.000
60-72	190.000	143.000
72-84	190.000	143.000

******** Alternate Intake ********

Month	Alternate (µg Pb/day)
6-12	0.000
12-24	0.000
24-36	0.000
36-48	0.000
48-60	0.000
60-72	0.000
72-84	0.000

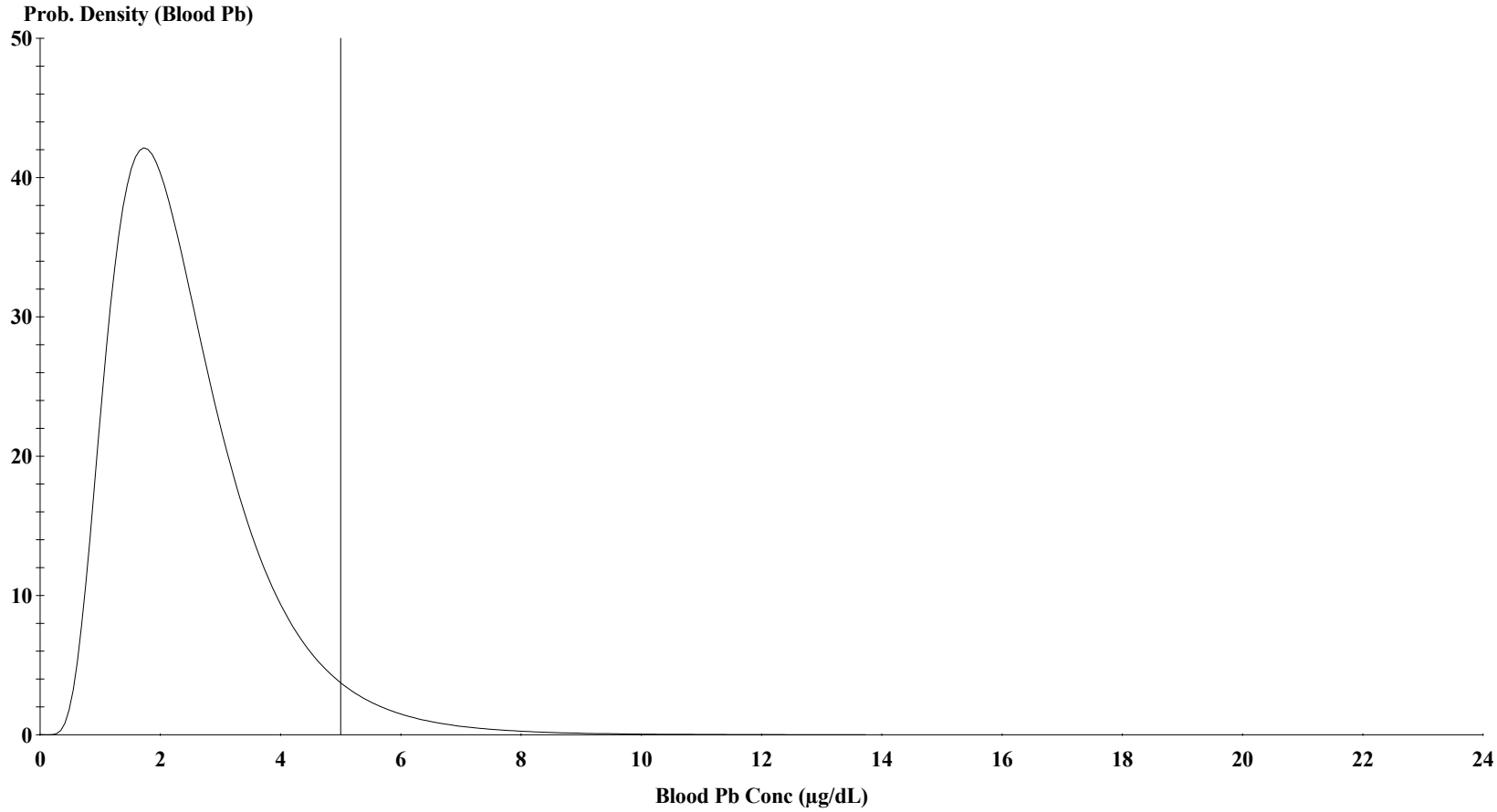
******** Maternal Contribution: Infant Model ********

Maternal Blood Concentration: 0.540 µg Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Month	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
6-12	0.034	1.251	0.000	0.169
12-24	0.057	2.367	0.000	0.182
24-36	0.075	2.494	0.000	0.220
36-48	0.093	2.593	0.000	0.234
48-60	0.102	2.727	0.000	0.248
60-72	0.111	2.938	0.000	0.263
72-84	0.118	2.899	0.000	0.276

Month	Soil+Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
6-12	3.982	5.436	2.9
12-24	4.357	6.964	2.9
24-36	3.159	5.948	2.3
36-48	2.990	5.910	2.1
48-60	3.190	6.267	2.0
60-72	2.491	5.803	1.9
72-84	2.639	5.933	1.7



Cutoff = 5.000 µg/dl
Geo Mean = 2.246
GSD = 1.600
% Above = 4.434
% Below = 95.566

Age Range = 12 to 72 months

Run Mode = Site Risk Assessment
Comment = Surface Soil

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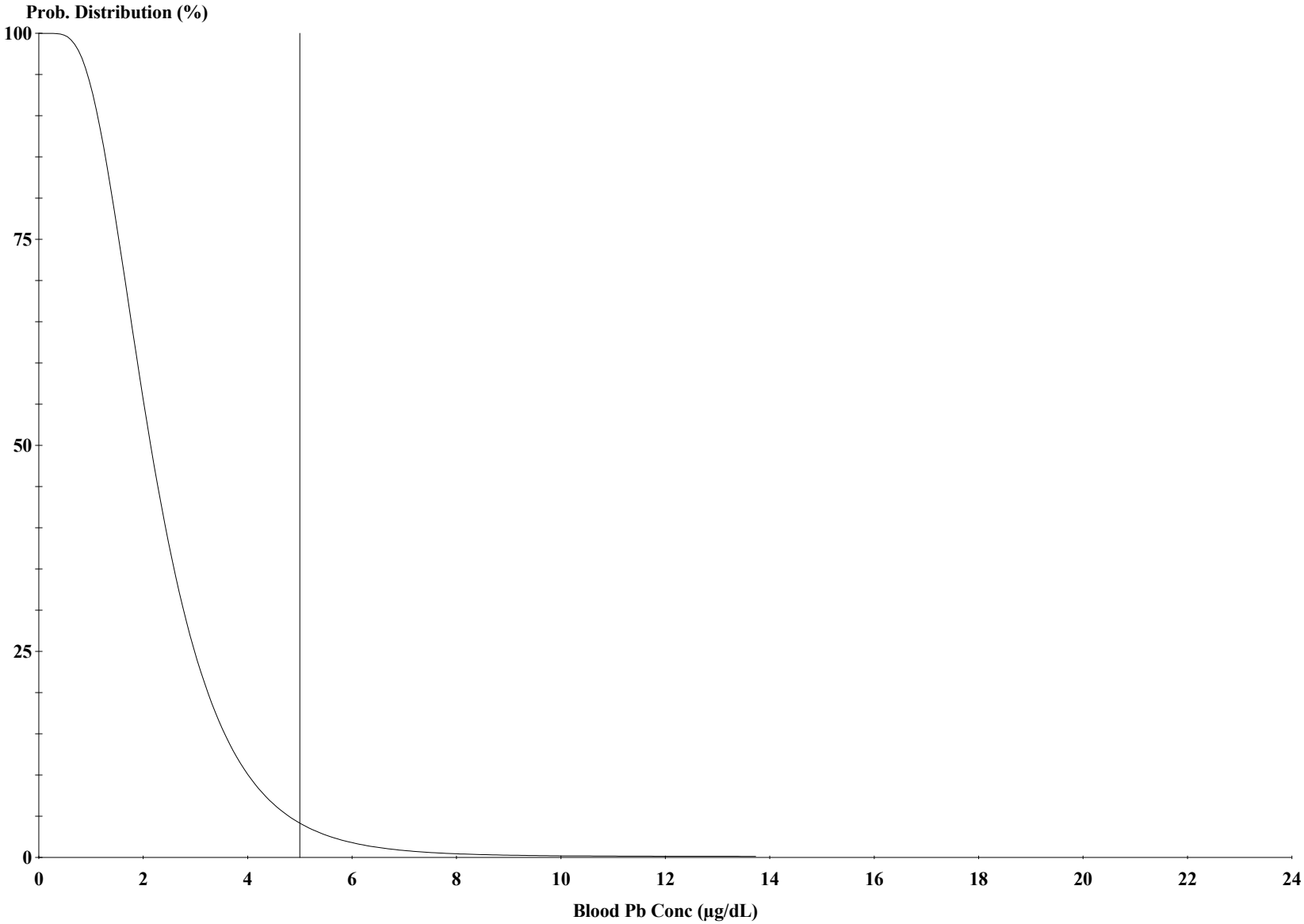

Cutoff = 5.000 µg/dl
Geo Mean = 2.246
GSD = 1.600
% Above = 4.434

Age Range = 12 to 72 months

Run Mode = Site Risk Assessment
Comment = Surface Soil

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LEAD MODEL FOR WINDOWS Version 2.0

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==========

Model Version: 2.0 Build1
User Name: Tetra Tech
Date: 02/21/2024
Site Name: NASA Wallops Island
Operable Unit: Southern Range Area - Subsurface Soil
Run Mode: Site Risk Assessment

 # Soil/Dust Data
Average concentration of lead in subsurface soil at Southern Range Area = 84.2 mg/kg.

==========

******** Air ********

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Month	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (µg Pb/m^3)
6-12	1.000	3.216	32.000	0.100
12-24	2.000	4.970	32.000	0.100
24-36	3.000	6.086	32.000	0.100
36-48	4.000	6.954	32.000	0.100
48-60	4.000	7.682	32.000	0.100
60-72	4.000	8.318	32.000	0.100
72-84	4.000	8.887	32.000	0.100

******** Diet ********

Month	Diet Intake(µg/day)
6-12	2.660
12-24	5.030
24-36	5.210
36-48	5.380
48-60	5.640
60-72	6.040
72-84	5.950

******** Drinking Water ********

Water Consumption:

Month	Water (L/day)
6-12	0.400
12-24	0.430
24-36	0.510
36-48	0.540
48-60	0.570
60-72	0.600
72-84	0.630

Drinking Water Concentration: 0.900 µg Pb/L

******** Soil & Dust ********

Multiple Source Analysis Used
Average multiple source concentration: 68.940 µg/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Month	Soil (µg Pb/g)	House Dust (µg Pb/g)
6-12	84.200	68.940
12-24	84.200	68.940
24-36	84.200	68.940
36-48	84.200	68.940
48-60	84.200	68.940
60-72	84.200	68.940
72-84	84.200	68.940

******** Alternate Intake ********

Month	Alternate (µg Pb/day)
6-12	0.000
12-24	0.000
24-36	0.000
36-48	0.000
48-60	0.000
60-72	0.000
72-84	0.000

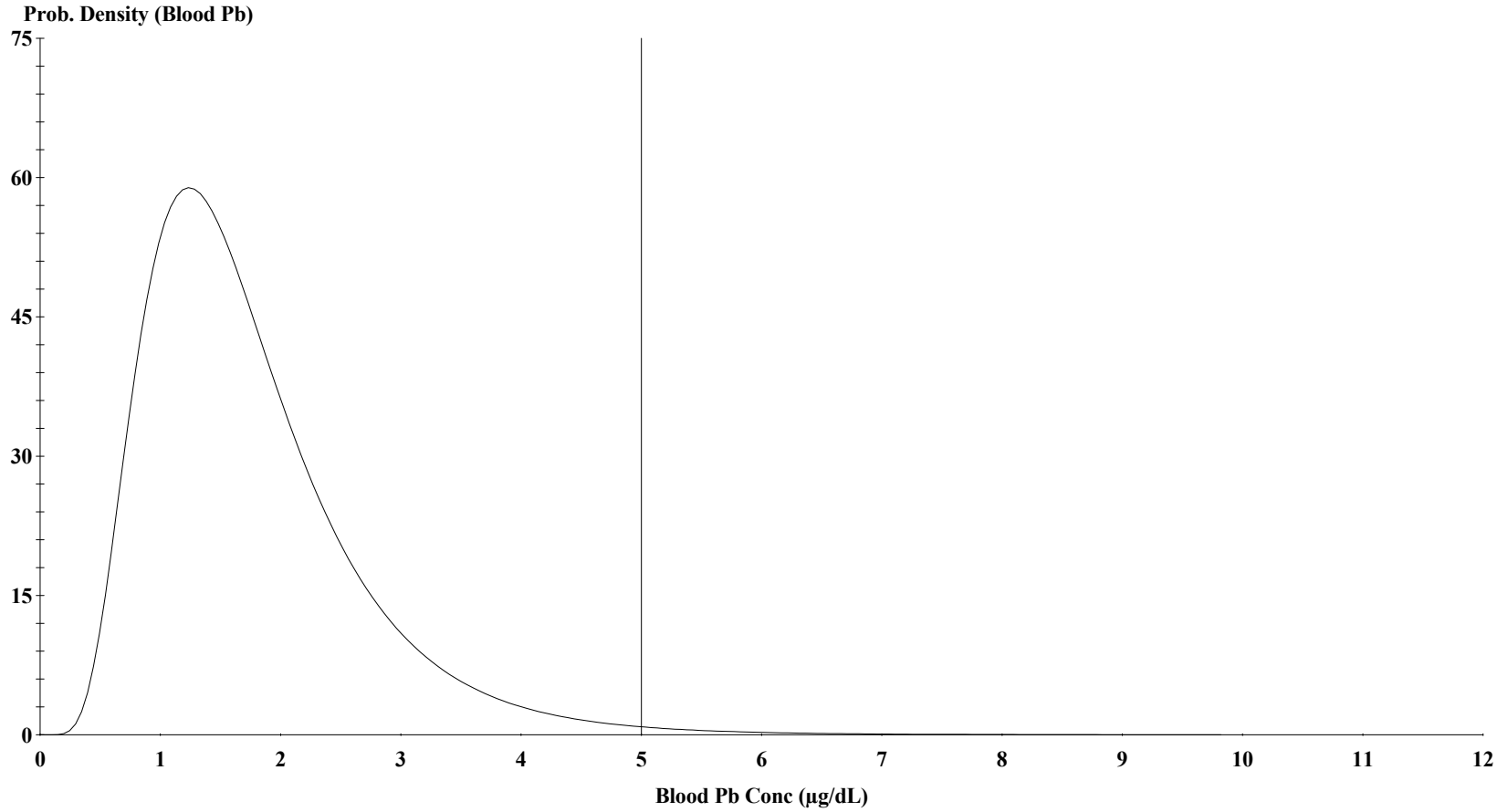
******** Maternal Contribution: Infant Model ********

Maternal Blood Concentration: 0.540 µg Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Month	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
6-12	0.034	1.281	0.000	0.173
12-24	0.057	2.415	0.000	0.186
24-36	0.075	2.525	0.000	0.222
36-48	0.093	2.619	0.000	0.237
48-60	0.102	2.752	0.000	0.250
60-72	0.111	2.957	0.000	0.264
72-84	0.118	2.917	0.000	0.278

Month	Soil+Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
6-12	1.883	3.371	1.8
12-24	2.053	4.711	1.9
24-36	1.477	4.300	1.7
36-48	1.395	4.343	1.5
48-60	1.487	4.591	1.5
60-72	1.158	4.490	1.4
72-84	1.227	4.540	1.3



Cutoff = 5.000 µg/dl
Geo Mean = 1.606
GSD = 1.600
% Above = 0.785
% Below = 99.215

Age Range = 12 to 72 months

Run Mode = Site Risk Assessment
Comment = Subsurface Soil

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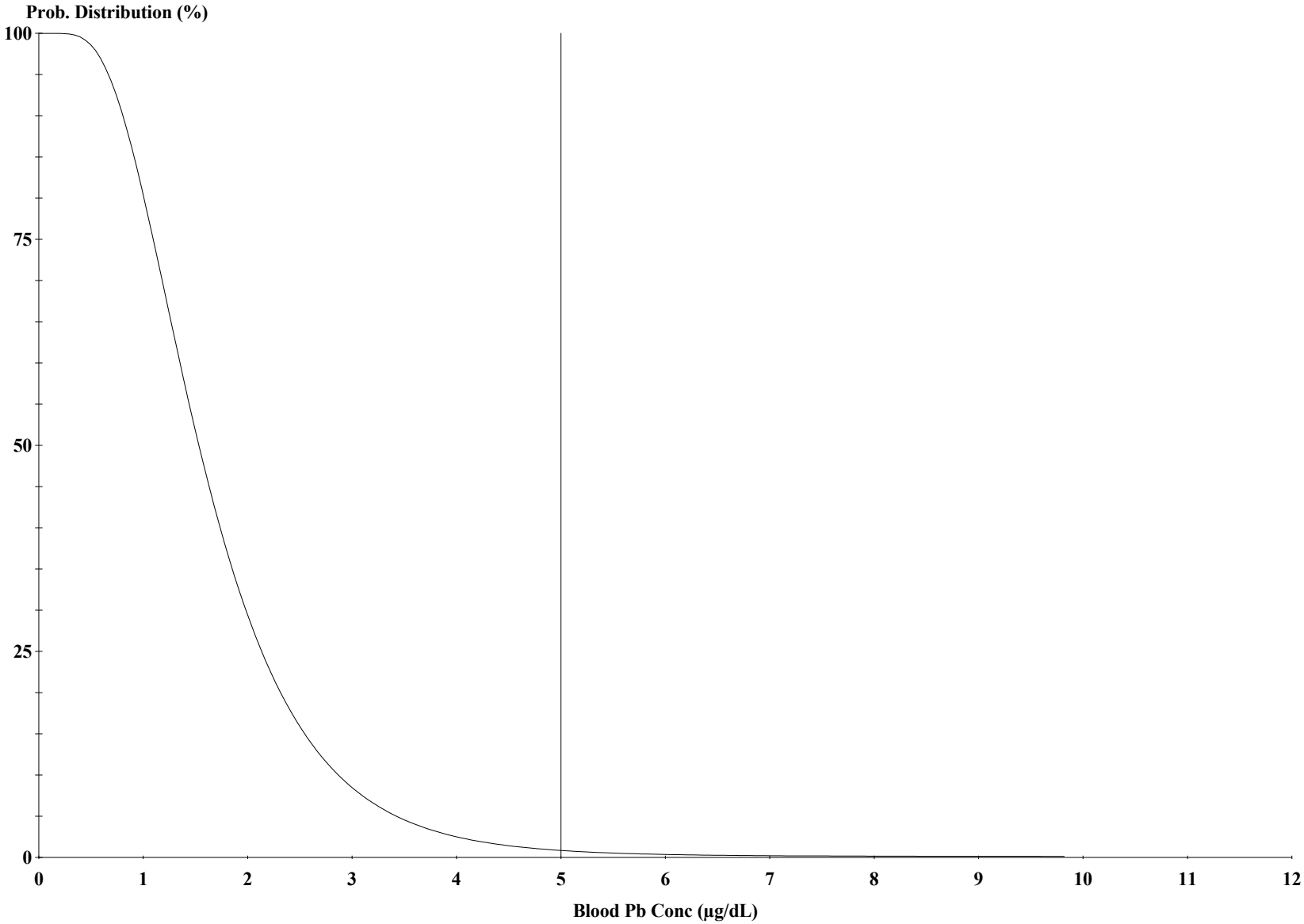

Cutoff = 5.000 µg/dl
Geo Mean = 1.606
GSD = 1.600
% Above = 0.785

Age Range = 12 to 72 months

Run Mode = Site Risk Assessment
Comment = Subsurface Soil

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LEAD MODEL FOR WINDOWS Version 2.0

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==========
Model Version: 2.0 Build1
User Name: Tetra Tech
Date: 02/21/2024
Site Name: NASA Wallops Island
Operable Unit: High Tower Area - Surface Soil
Run Mode: Site Risk Assessment

 # Soil/Dust Data
Average concentration of lead in High Tower Area surface soil = 117 mg/kg.
==========

******** Air ********

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Month	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (µg Pb/m^3)
6-12	1.000	3.216	32.000	0.100
12-24	2.000	4.970	32.000	0.100
24-36	3.000	6.086	32.000	0.100
36-48	4.000	6.954	32.000	0.100
48-60	4.000	7.682	32.000	0.100
60-72	4.000	8.318	32.000	0.100
72-84	4.000	8.887	32.000	0.100

******** Diet ********

Month	Diet Intake(µg/day)
6-12	2.660
12-24	5.030
24-36	5.210
36-48	5.380
48-60	5.640
60-72	6.040
72-84	5.950

******** Drinking Water ********

Water Consumption:

Month	Water (L/day)
6-12	0.400
12-24	0.430
24-36	0.510
36-48	0.540
48-60	0.570
60-72	0.600
72-84	0.630

Drinking Water Concentration: 0.900 µg Pb/L

******** Soil & Dust ********

Multiple Source Analysis Used
Average multiple source concentration: 91.900 µg/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Month	Soil (µg Pb/g)	House Dust (µg Pb/g)
6-12	117.000	91.900
12-24	117.000	91.900
24-36	117.000	91.900
36-48	117.000	91.900
48-60	117.000	91.900
60-72	117.000	91.900
72-84	117.000	91.900

******** Alternate Intake ********

Month	Alternate (µg Pb/day)
6-12	0.000
12-24	0.000
24-36	0.000
36-48	0.000
48-60	0.000
60-72	0.000
72-84	0.000

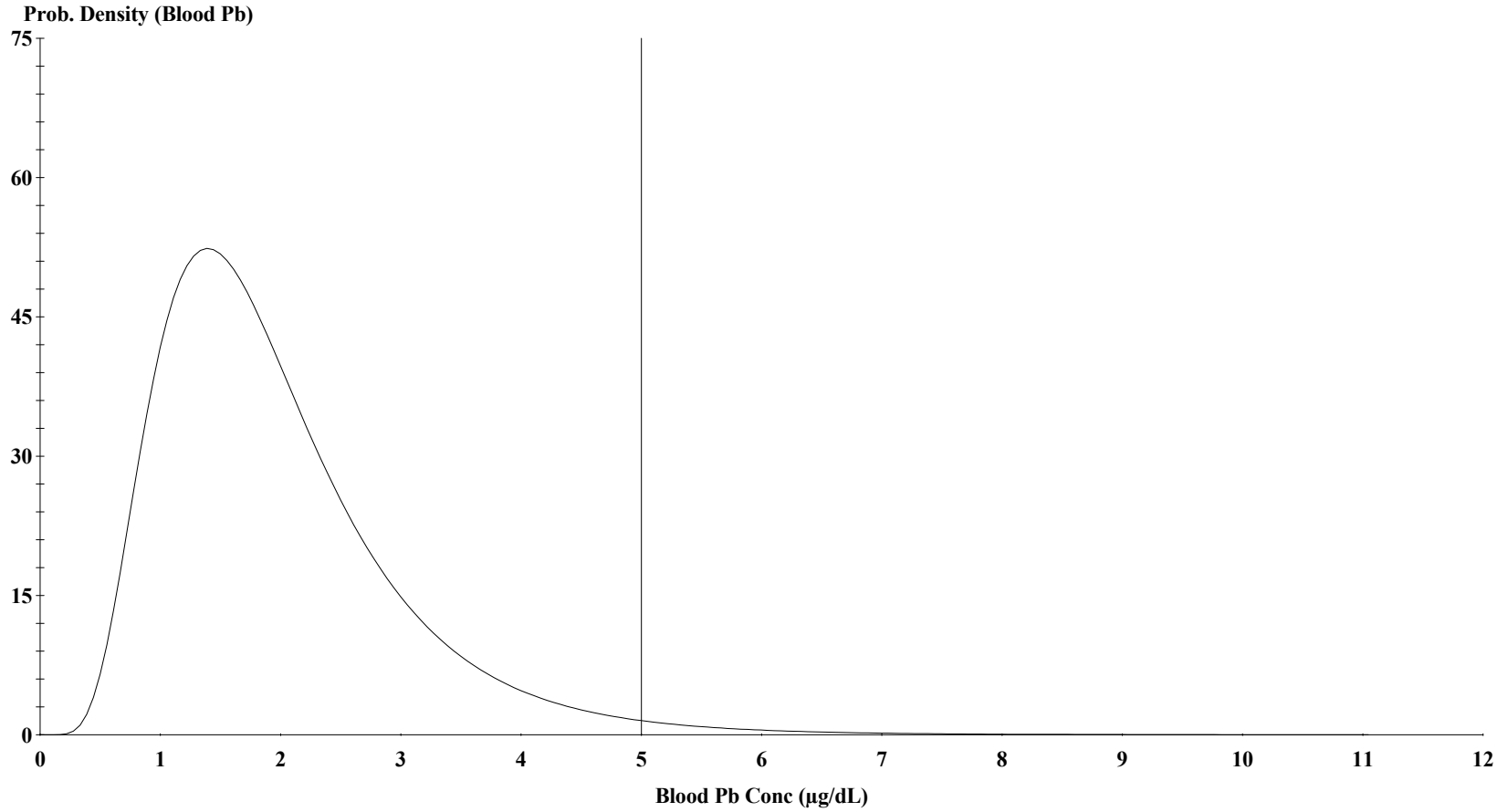
******** Maternal Contribution: Infant Model ********

Maternal Blood Concentration: 0.540 µg Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Month	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
6-12	0.034	1.271	0.000	0.172
12-24	0.057	2.400	0.000	0.185
24-36	0.075	2.515	0.000	0.222
36-48	0.093	2.611	0.000	0.236
48-60	0.102	2.744	0.000	0.250
60-72	0.111	2.951	0.000	0.264
72-84	0.118	2.912	0.000	0.277

Month	Soil+Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
6-12	2.545	4.022	2.2
12-24	2.777	5.419	2.3
24-36	2.003	4.815	1.9
36-48	1.893	4.832	1.7
48-60	2.018	5.114	1.7
60-72	1.573	4.899	1.5
72-84	1.666	4.974	1.4



Cutoff = 5.000 µg/dl
Geo Mean = 1.807
GSD = 1.600
% Above = 1.517
% Below = 98.483

Age Range = 12 to 72 months

Run Mode = Site Risk Assessment
Comment = Surface Soil

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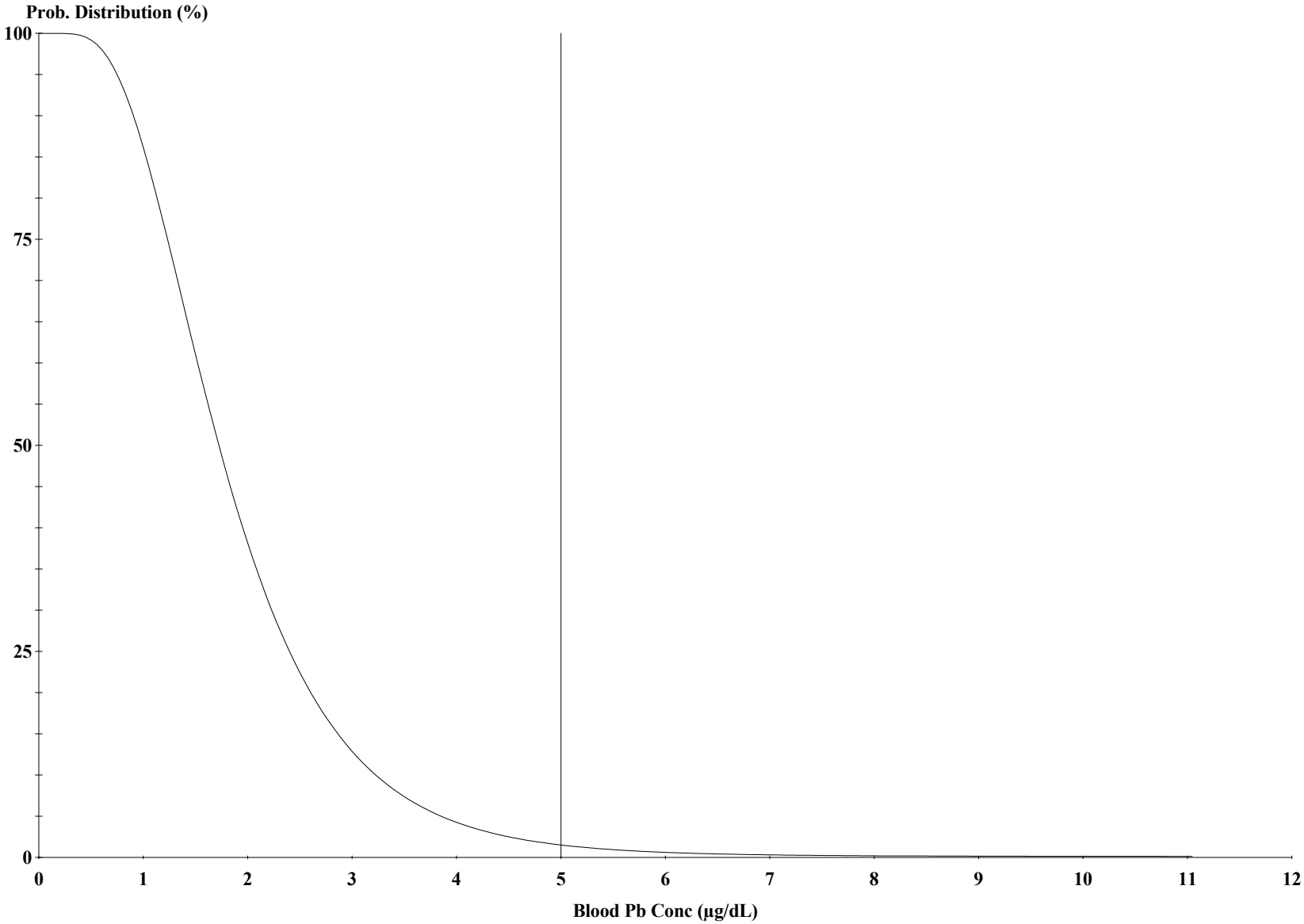

Cutoff = 5.000 µg/dl
Geo Mean = 1.807
GSD = 1.600
% Above = 1.517

Age Range = 12 to 72 months

Run Mode = Site Risk Assessment
Comment = Surface Soil

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate.
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ADULT LEAD MODEL RESULTS

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SITE NAME: NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA
LOCATION: NORTHERN RANGE AREA - SURFACE SOIL
RECEPTOR: INDUSTRIAL WORKERS
MEDIA: SURFACE SOIL
DATE: MAY 6, 2019

Calculations of Blood Lead Concentrations (PbBs) and Risk in Nonresidential Areas

U.S. EPA Technical Review Workgroup for Lead

Version date 06/14/2017

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014
PbS	Soil lead concentration	µg/g or ppm	1,107
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	µg/dL	0.6
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	PbB of adult worker, geometric mean	µg/dL	2.2
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	5.2
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**5.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB, assuming lognormal distribution**	**%**	**5.70%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

SITE NAME: NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA
LOCATION: NORTHERN RANGE AREA - SUBSURFACE SOIL
RECEPTOR: INDUSTRIAL WORKERS
MEDIA: SUBSURFACE SOIL
DATE: MAY 6, 2019

Calculations of Blood Lead Concentrations (PbBs) and Risk in Nonresidential Areas

U.S. EPA Technical Review Workgroup for Lead

Version date 06/14/2017

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014
PbS	Soil lead concentration	µg/g or ppm	170
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	µg/dL	0.6
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	PbB of adult worker, geometric mean	µg/dL	0.8
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	2.0
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**5.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB, assuming lognormal distribution**	**%**	**0.07%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

SITE NAME: NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA
LOCATION: SOUTHERN RANGE AREA - SURFACE SOIL
RECEPTOR: INDUSTRIAL WORKERS
MEDIA: SURFACE SOIL
DATE: MAY 6, 2019

Calculations of Blood Lead Concentrations (PbBs) and Risk in Nonresidential Areas

U.S. EPA Technical Review Workgroup for Lead

Version date 06/14/2017

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014
PbS	Soil lead concentration	µg/g or ppm	190
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	µg/dL	0.6
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	PbB of adult worker, geometric mean	µg/dL	0.9
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	2.1
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**5.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB, assuming lognormal distribution**	**%**	**0.08%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

SITE NAME: NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA
LOCATION: SOUTHERN RANGE AREA - SUBSURFACE SOIL
RECEPTOR: INDUSTRIAL WORKERS
MEDIA: SUBSURFACE SOIL
DATE: MAY 6, 2019

Calculations of Blood Lead Concentrations (PbBs) and Risk in Nonresidential Areas

U.S. EPA Technical Review Workgroup for Lead

Version date 06/14/2017

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014
PbS	Soil lead concentration	µg/g or ppm	84.2
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	µg/dL	0.6
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	PbB of adult worker, geometric mean	µg/dL	0.7
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	1.7
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**5.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB, assuming lognormal distribution**	**%**	**0.03%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

SITE NAME: NASA WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA
LOCATION: HIGH TOWER AREA - SURFACE SOIL
RECEPTOR: INDUSTRIAL WORKERS
MEDIA: SURFACE SOIL
DATE: FEBRUARY 21, 2024

Calculations of Blood Lead Concentrations (PbBs) and Risk in Nonresidential Areas

U.S. EPA Technical Review Workgroup for Lead

Version date 06/14/2017

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014
PbS	Soil lead concentration	µg/g or ppm	117
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	µg/dL	0.6
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	PbB of adult worker, geometric mean	µg/dL	0.8
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	1.8
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**5.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB, assuming lognormal distribution**	**%**	**0.04%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

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