National Aeronautics and Space Administration

Record of Decision

Operable Unit 4
Project 15 – Active Remediation Projects
Site 9 – Drum Disposal Area
Soil, Sediment, and Surface Water

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia

April 2021

TABLE OF CONTENTS

TABLE OF CONTENTS CONTINUED

Tables

Figures

ACRONYMS AND ABBREVIATIONS

1,2-DCE	1,2-dichloroethene
ADAF	age-dependent adjustment factor
AOC	Area of Concern
BAF	bioaccumulation factor
BHHRA	baseline human health risk assessment
BTAG	Biological Technical Assistance Group
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CDI	chronic daily intake
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-dichloroethene
CNAAS	Chincoteague Naval Auxiliary Air Station
COC	chemical of concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSF	cancer slope factors
CSM	conceptual site model
DCE	dichloroethene
DDD	dichlorodiphenyltrichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DOD	Department of Defense
ECO SSL	Ecological Soil Screening Level
EPI	Environmental Priorities Initiative
ERA	ecological risk assessment
ESS	environmental site survey
FFTA	Former Fire Training Area
FS	feasibility study
FUDS	formerly used defense site
GSFC	Goddard Space Flight Center
HI	hazard index
HQ	hazard quotient
ILCR	incremental lifetime cancer risk
IUR	inhalation unit risks
LOAEL	lowest observed adverse effect level
MOA	Memorandum of Agreement
MCL	maximum contaminant level
mg/kg	milligram per kilogram

ACRONYMS AND ABBREVIATIONS CONTINUED

mg/kg-day	milligram per kilogram per day
mg/L	milligrams per liter
NAOTS	Naval Aviation Ordnance Test Station
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAEL	no observed adverse effect level
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PP	Proposed Plan
ppm	parts per million
RBCs	risk based concentrations
RFA	RCRA Facility Assessment
RCRA	Resource Conservation Recovery Act
RfC	reference concentration
RfD	reference dose
RI	Remedial Investigation
RSL	Regional Screening Levels
ROD	Record of Decision
SF	slope factor
SI	Site Investigation
SSL	soil screening level
SVOC	semivolatile organic compound
TCE	trichloroethene
TCLP	toxicity characteristic leaching procedure
TCRA	Time Critical Removal Action
TRV	toxicity reference value
USACE	Unites States Army Corps of Engineers
U.S.C.	United States Code
USEPA	United States Environmental Protection Agency
VAGQS	VDEQ Groundwater Quality Standards
VDEQ	Virginia Department of Environmental Quality
VPDES	Virginia Pollutant Discharge Elimination System
VOC	volatile organic compound
WFF	Wallops Flight Facility

ACRONYMS AND ABBREVIATIONS CONTINUED

WOD	Waste Oil Dump
WWTP	Waste Water Treatment Plant
µg/L	microgram per liter
µg/kg	microgram per kilogram

1.0 DECLARATION

1.1 SITE NAME AND LOCATION

Operable Unit (OU) 4
Project 15 – Active Remediation Projects
Site 9 – Drum Disposal Area
Formerly Used Defense Site
NASA Wallops Flight Facility
Wallops Island, Virginia

1.2 STATEMENT OF BASIS AND PURPOSE

This decision document presents the Record of Decision (ROD) for Site 9 – Drum Disposal Area, OU-4, Formerly Used Defense Site (FUDS) soil, sediment, and surface water 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 (U.S.C.) 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 and the United States Environmental Protection Agency (USEPA) jointly selected the remedy, and the Virginia Department of Environmental Quality (VDEQ) concurs with the Selected Remedy.

1.3 ASSESSMENT OF SITE

NASA and the USEPA have determined that no further action for soil, sediment, and surface water is necessary to protect public health or welfare or the environment. However, groundwater contamination at Site 9 poses an unacceptable risk and will be addressed separately.

1.4 DESCRIPTION OF SELECTED REMEDY

No further action is necessary for soil, sediment, and surface water at Site 9. Action for groundwater will be addressed in a separate ROD.

1.5 STATUTORY DETERMINATIONS

NASA and USEPA have determined, and VDEQ concurred, that no further remedial action is necessary for soil, sediment, and surface water at the Site to ensure protection of public health or welfare or the environment. A Removal Action, conducted at the Site in 2005, removed the drums and contaminated soil,

thereby eliminating the need to conduct further remedial action for soil. Post-Removal Action sampling and studies conducted from 2008 through 2009, confirmed that no further action is required for soil, surface water, and sediment. However, groundwater will be further evaluated under a separate action.

The No Further Action remedy will not result in hazardous substances, pollutants, or contaminants remaining on Site above levels that allow for unlimited use and unrestricted exposure for soil, surface water and sediment. Therefore, a five-year review will not be required for the Site for these media.

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 (See Table in Section 2.5.4: Nature and Extent of Contamination).
- ✓ Baseline risk represented by the COCs.
- ✓ Current and reasonably anticipated future land use assumptions and current and beneficial uses of groundwater used in the baseline risk assessment and ROD (See Section 2.6 Current and Potential Future Land and Resource Uses).
- ✓ 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 Digitally signed by DAVID RETH Date: 2021.04.29 09:00:07 -04'00'

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

KRISTEEN GAFFNEY Digitally signed by KRISTEEN GAFFNEY Date: 2021.04.29 11:43:12 -04'00'

Kristeen Gaffney, Chief — Date
Federal Facilities and Site Assessment Branch
Superfund & Emergency Management Division
USEPA Region 3

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). Site 9 is located on 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 1,927 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 Marine Science Consortium, 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.

Site 9 encompasses approximately 91,000 square feet (2.1 acres) northwest of Runway 17-35 and the abandoned taxiway that parallels Runway 10-28 in the north-central portion of the Main Base. Site 9 is comprised mainly of heavily vegetated and wooded land (Figures 2-3 and 2-4). It is bounded to the north by a stormwater drainage culvert and the northern terminus of Runway 17-35, to the east by grassy land situated adjacent to (west of) Runway 17-35, and to the south and west by undeveloped woodland, wetlands, and an unnamed intermittent tributary of Little Mosquito Creek. The surficial aquifer groundwater flows in a westerly direction toward the wetlands and the unnamed tributary (Figure 2-5).

Site 9 was investigated under the United States Army Corps of Engineers (USACE) FUDS program. In 2015, NASA and the Department of Defense (DOD), through the Department of the Army, executed a Memorandum of Agreement (MOA) delegating CERCLA response action authority for the FUDS Program at NASA WFF to NASA (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 the WFF. USEPA is the lead regulatory agency, and VDEQ is the support agency. Funding is provided through the USACE.

In the early 1990s, Site 9 was identified during a NASA survey of stormwater discharge points at WFF. Several abandoned deteriorated drums were found protruding from the ground surface, and a tar-like substance was emanating from some of the drums. The significant growth of trees and underbrush at the Site, along with the deteriorated condition of the drums, indicated that the drum disposal had occurred several decades earlier.

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 (NAOTS) was established on the Wallops Island portion of CNAAS. All real property at the Main Base Parcel (CNAAS and NAOTS) was initially leased to NASA in June 1959 and transferred to NASA on December 1, 1961. 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.

2.2.2 Previous Investigations, Removal Actions, and Enforcement Actions

Site 9 was identified during an environmental site survey (ESS) conducted in 1990 (Ebasco, 1990). Several abandoned, deteriorated drums were reported to be protruding from the ground surface, and a tar-like substance was emanating from some of the drums. The ESS concluded that additional investigation at Site 9 was warranted because current information was not available for the site at that time.

In 1992, a Resource Conservation Recovery Act (RCRA) Facility Assessment (RFA) / Environmental Priorities Initiative (EPI) identified Site 9 as an area of concern (AOC) on the WFF Main Base. During the onsite survey, severely weathered and deteriorated drums were observed at several areas within the tree line of Site 9. The wooded area also contained many unnatural earthen mounds, possibly suggesting the presence of buried drums. The nature and extent of waste contained in Site 9 were not determined during the RFA/EPI (Versar, 1992).

In March 1993, a soil gas survey was completed at Site 9 as part of a multiphase Site Investigation (SI) of 15 separate sites at WFF. Seven soil gas samples were collected at variable depths (ranging from two to eight feet below ground surface) within and adjacent to Site 9. Sample locations were selected based on visible signs of potential releases and impacts and the results of the magnetometer survey. One soil gas sample collected near a mound of partially buried drums revealed volatile organic compounds (VOCs) at 0.2 parts per million (ppm).

A magnetometer survey was conducted at Site 9 in July 1993. It was estimated that Site 9 was approximately 600 feet long and ranged in width from 20 to 200 feet. During the survey, 20 subsurface anomalies were identified as possible 55-gallon drums. The preliminary SI report recommended that the subsurface locations be surveyed during a later phase of the SI to produce a record of their locations (M&E, 1993a).

The second phase of the SI (M&E, 1993b) recommended sample collection and analysis of the tar-like substance in the abandoned drums, as well as surface water and sediment from the nearby intermittent streams to Little Mosquito Creek.

Between June 1993 and September 1995, soil samples were collected from Site 9, and sediment and surface water samples were collected from the unnamed tributary to Little Mosquito Creek. Three monitoring wells were installed, and groundwater samples were collected from these wells. A sample of the tar-like residue from an abandoned drum was also collected. The SI recommended the removal of the drums and their contents to prevent further potential releases to soil, groundwater, surface water, and sediment (M&E, 1996).

In May 2005, a Time Critical Removal Action (TCRA) was conducted to remove the abandoned drums and tar-like material at Site 9. The tar-like material was sampled and characterized for disposal. Samples were analyzed for VOCs, semivolatile organic compounds (SVOCs), and metals via toxicity characteristic leaching procedure (TCLP). Samples were also analyzed for general chemistry parameters, including pH, total cyanide, ignitability, percent solids, and total sulfide. TCLP results of the tarlike material detected four metals [arsenic (0.17 milligram per liter [mg/L]), barium (0.15 mg/L), lead (0.021 mg/L), and silver (0.0022 mg/L)] and two organic compounds [benzene (0.038 mg/L) and cresols (0.26 mg/L)] in the sample (MicroPact Engineering, Inc. 2005). Analytical results indicated that the material was nonhazardous. The TCRA included the excavation of empty drums along with drums partially full of tar-like material. Bulk tar-like material was also excavated from the subsurface in areas below and around the drums. At the time, a layer of the tar-like material in subsurface soils was left in place in a portion of the site because resources to properly remove the layer were not available.

In October 2005, removal of tar-like material identified and left in place in May was completed at Site 9. Additional tar-like material and several additional drums were removed from surface and subsurface soil in two areas on-site, see Figure 2-3. All excavated areas were backfilled and graded to match existing topography. All drums and tar-like material previously identified on site had been removed (MicroPact, 2005).

In January 2008, soil, groundwater, surface water, and sediment assessment activities were conducted at Site 9 to assess the 2005 TCRA and to further evaluate these media to support a Remedial Investigation (RI). Field investigations included visually inspecting the surface and shallow subsurface soil for the presence of tar-like material, which was completed by advancing 28 soil borings and excavating 29 test pits (Figure 2-4. At three areas, “chunks” of tar-like material ranging from 1/8 inch to 1.5 feet were observed on the surface and in the upper 1.5 feet of soil underlying Site 9. The material was found to be localized and limited in extent at all three locations and located in close proximity to the areas encompassed by the 2005 TCRA. An estimated 10 gallons of tar-like material were removed from the three locations and containerized for characterization and proper disposal (ICOR, 2008).

In September 2008, temporary wells were installed to further delineate the extent of groundwater contamination. The temporary wells were installed primarily upgradient of Site 9, along both sides (east and west) of Runway 17-35. In addition to the temporary wells, groundwater samples were collected from the three Site 9 wells and a permanent well associated with the former Waste Water Treatment Plant (WWTP) Site.

In June 2009, three new groundwater monitoring wells were installed at Site 9. All three new wells were installed topographically and hydraulically downgradient of existing well MW1 and in areas where the three localized areas of tar-like material were located in 2008 (ICOR, 2010).

No other enforcement activities, removal actions, or remediation activities have been initiated at Site 9.

2.3 COMMUNITY PARTICIPATION

The Proposed Plan (PP) and the RI/ Feasibility Study (FS) for Site 9 was made available to the public on May 25, 2016. These documents can be found in the Administrative Record file and the Information Repositories maintained at the Eastern Shore Public Library (23610 Front Street, Accomack, Virginia 23301) and Island Library (4077 Main Street, Chincoteague, Virginia 23336). The notice of availability of the PP was placed in the Chincoteague Beacon and Eastern Shore News on May 25, 2016. A public comment period was held from May 27, 2016 to June 27, 2016. No comments were received during the comment period as noted in the Responsiveness Summary section of this ROD.

2.4 SCOPE AND ROLE OF RESPONSE ACTION

Site 9 is identified as OU-4, which is one of nine OUs at NASA WFF being addressed under CERCLA. Currently, there are three OUs with RODs in place. The OU-1 (Scrapyard Site N-222) ROD was completed in 2008 and was closed with a No Further Action decision. The OU-2 (Former Fire Training Area) ROD was completed in 2007. The final remedy (biostimulation, institutional controls, and monitoring) documented in the OU-2 ROD was implemented, and long-term monitoring and reporting is ongoing. The OU-3 Waste Oil Dump ROD was completed in 2008. The final remedy (biostimulation, institutional controls, and monitoring) documented in the OU-3 ROD was implemented, and long-term monitoring and reporting is ongoing.

Three of the remaining OUs are currently in the RI/FS phase: the Construction Debris Landfill (OU-7), the Skeet Range (OU-8), and the Boat Basin and Visitor's Center (OU-9).

The final three OUs, including Site 9, are anticipated to have RODs in place in FY22. The other two OUs with anticipated RODs are Site 14 and 15 Debris Piles identified as OU-5 and the Old Wastewater Treatment Plant (WWTP) identified as OU-6.

This ROD applies to Site 9 only and specifically addresses soil, sediment, and surface water at Site 9. The 2005 TCRA removed the source of contamination (drums) and addressed surface and subsurface soil

contamination. An RI was conducted in 2008 to assess the TCRA and approximately 10 gallons of tar-like material was removed from subsurface soils. Sidewall samples were collected from test pits to confirm the removal of all source material. In addition, sampling and evaluation of surface water and sediment determined that there is no unacceptable risk associated with these media. As a result, No Further Action was chosen for soils, sediment, and surface water at Site 9. Groundwater at Site 9 is being addressed under a separate investigation.

2.5 SITE CHARACTERISTICS

2.5.1 Physical Setting

Site 9 is situated at the base of a sloping hill that consists of approximately 20 feet of topographic relief (Figure 2-3). The Site slopes gradually to the west, towards wetlands contiguous with the unnamed tributary to Little Mosquito Creek. Soils beneath Site 9 generally consist of light brown to tan silty sand and sand, with traces of clay, and minor amounts of gravel. Shallow groundwater flow direction is generally to the west towards the unnamed tributary to Little Mosquito Creek (Figure 2-5). No perennially flowing surface water bodies are located on or adjacent to Site 9. Stormwater runoff from the site flows overland in a westerly direction and discharges into the intermittent streams/stormwater drainage ditch. The intermittent stream originates at the discharge points of two permitted outfalls for the WFF stormwater collection network: Virginia Pollution Discharge Elimination System (VPDES) Outfall 013 and Outfall 005 (Figure 2-3). This outfall and drainage ditch also receives runoff from the nearby runway, taxiways and ramp areas during precipitation events.

The geology underlying Site 9 is characterized by layers of unconsolidated sediments (sand, silt, gravel) over deeply buried bedrock. Shallow unconsolidated sediments consist of the Pleistocene and Holocene Columbia Group which occurs to a depth of approximately 60 feet in the WFF area. The underlying Yorktown Formation is the uppermost unit in the Chesapeake Group and occurs at depths of 60 to 140 feet in Accomack County. The Columbia Group is separated from the underlying Yorktown Formation by a 20- to 40-foot thick clay and silt layer. Groundwater within the shallower Columbia Group is unconfined and flow follows the local topography. Groundwater in the deeper Yorktown Formation is separated from the overlying Columbia water table aquifer by the clay and silt confining layer (aquitard). The Yorktown Formation aquifer is a confined aquifer and generally flows to the east northeast.

Groundwater is the only source for drinking, agricultural, and process water within the WFF area. The withdrawal of groundwater from the area, including Accomack County, is controlled through the issuance of withdrawal permits under the Virginia Groundwater Management Act. The Virginia State Water Control Board, in consultation with the local planning commissions and the Department of Health, administers the permitting program and allocates groundwater withdrawal volumes as part of the permitting process.

2.5.2 Conceptual Site Model

Figure 2-6 presents the Conceptual Site Model (CSM) for human receptors. Figure 2-7 and Figure 2-8 present the CSMs for the terrestrial and aquatic ecosystem. 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

Site 9 RI field investigation activities were conducted in 2008 and 2009 to evaluate the nature and extent of contamination after the completion of the 2005 TCRA (Weston, 2013a). The investigation included soil, sediment, surface water, and groundwater sampling. Sampling locations are presented on Figure 2-4.

Soil investigation and sampling included 28 test borings and 29 test pits for the purpose of visually inspecting soil for the presence of tar-like material and collecting surface and subsurface soil samples. Test borings were advanced using direct-push technology in areas identified during the 2005 TCRA as containing remnant deposits of tar-like material. Soil cores were screened visually and by a photoionization detector for the presence of VOCs. All areas exhibiting potential evidence of impact were targeted for sampling. Surface and subsurface samples were collected and analyzed for VOCs, SVOCs, metals, pesticides, and polychlorinated biphenyl (PCBs).

Test pits were excavated by a mini-excavator in areas that were inaccessible to direct push sampling. Test pits were initially excavated in areas identified during the TCRA as containing remnant deposits of tar-like material, areas adjacent to locations where drums and tar-like deposits were removed during the TCRA, and areas where tar-like deposits were identified during RI field work. Soil sampling was conducted continuously during the excavation until target depth was achieved (a depth corresponding to fill/native soil interface or soil/groundwater interface). Samples were collected from the sidewall and analyzed for VOCs, SVOCs, metals, pesticides, and PCBs.

Sediment and surface water samples were collected from three locations along the intermittent stream/drainage ditch located along the western boundary of Site 9 (Figure 2-4). Sediment and surface water samples were analyzed for VOCs, SVOCs, metals, pesticides, and PCBs.

Groundwater samples were collected from six monitoring wells (Figure 2-4). Groundwater samples were analyzed for VOCs, SVOCs, total and dissolved metals, pesticides, and PCBs.

2.5.4 Nature and Extent of Contamination

Soil

During the January 2008 field investigation, 15 soil boring samples and 17 test pit soils samples were collected to characterize the nature and extent of contamination on-site. Analytical results were compared to the 2009 USEPA Regional Screening Levels (RSLs) Table for Residential and Industrial Soil and Air. The non-carcinogenic RSLs were adjusted by a factor of 0.1 to account for additive effects. Analytical results were also compared to WFF background concentrations, which were from the Final Background Soil and Groundwater Investigation Report for the Main Base, NASA WFF (Tetra Tech, 2004).

Fourteen metals (aluminum, arsenic, barium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, vanadium, and zinc) were detected in soil samples. Aluminum, arsenic, iron, and vanadium were detected at concentrations exceeding residential direct contact screening levels. Arsenic and vanadium were also detected at concentrations exceeding the industrial direct contact screening level. The concentrations of four metals (arsenic, iron, manganese, and mercury) exceeded the soil to groundwater risk based soil screening levels (SSLs). A summary of the exceedances associated with the four metals is presented as follows:

- Aluminum was detected in all soil samples at concentrations ranging from 2,450 to 13,700 milligrams per kilograms (mg/kg), with 16 samples exceeding the residential direct contact screening level of 7,700 mg/kg. The aluminum concentrations detected are within the background range of 1,870 to 13,900 mg/kg.
- Arsenic concentrations ranged from 2.2 to 3.4 mg/kg, with six samples exceeding the residential and industrial direct contact screening levels of 0.39 mg/kg and 1.59 mg/kg, respectively. The arsenic concentrations detected were on the low end of the background range of 0.78 to 14.2 mg/kg.
- Iron was detected in all soil samples at concentrations ranging from 1,330 to 8,120 mg/kg, with five soil samples exceeding the residential direct contact screening level of 5,500 mg/kg. The iron concentrations detected are within the background range of 1,740 to 10,900 mg/kg.
- Vanadium was detected at concentrations ranging from 7.6 to 16.8 mg/kg, with 23 samples exceeding the residential and industrial direct contact screening levels of 0.55 mg/kg and 7.15 mg/kg, respectively. The vanadium concentrations detected are within the background range of 3.5 to 28.5 mg/kg.

In summary, based on the concentrations detected as compared to the background range, metals detected in soil at the Site are attributable to background concentrations and are not indicative of a release or source area.

Four pesticides were detected in one or more soil samples including 4,4'-dichloro-diphenyl-dichloroethane (DDD), 4,4'-dichloro-diphenyl-dichloroethylene (DDE), 4,4'-dichloro-diphenyl-trichloroethane (DDT), and methoxychlor. DDD was detected at a range of 2.3 to 3.7 micrograms per kilograms (µg/kg), DDE was detected at a range of 1.7 to 149 µg/kg, DDT was detected at a range of 1.4 to 174 µg/kg, and methoxychlor was detected at one location at 2.4 µg/kg. The detected concentration of these pesticides in all soil samples are below residential direct contact screening levels. Residual levels of pesticides present in soil are likely a result of former pest control at WFF.

Several SVOCs were detected in the soil samples: polycyclic aromatic hydrocarbons (PAHs); acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene. Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene were detected in at least one soil sample at concentrations exceeding their respective residential direct contact screening levels. Benzo(a)pyrene was the only chemical detected at concentrations exceeding the industrial direct contact screening levels. Soil to groundwater risk based SSLs were exceeded for five PAHs detected in site soils. A summary of these compounds is presented as follows:

- Benzo(a)anthracene was detected in three soil samples at a range of 36.4 to 368 µg/kg, with two samples at concentrations exceeding the residential direct contact screening level of 150 µg/kg.
- Benzo(a)pyrene was detected in three soil samples at a range of 45.3 to 486 µg/kg with all detected concentrations exceeding the residential direct contact screening level of 15 µg/kg, and two soil samples exceeding the residential direct contact screening level of 150 µg/kg.
- Benzo(b)flouranthene was detected in three soil samples at a range of 29.2 to 297 µg/kg, with two samples at concentrations exceeding the residential direct contact screening level of 150 µg/kg.
- Debenz(a,h)anthracene was detected in two soil samples at a range of 57.1 to 70 µg/kg, with both detected concentrations exceeding the residential direct contact screening level of 15 µg/kg.
- Indeno(1,2,3-cd)pyrene was detected in two soil samples at a range of 175 to 225 µg/kg, with both detected concentrations exceeding the residential direct contact screening level of 150 µg/kg.

Site 9 PAH concentrations were compared to background concentrations. PAH compounds are commonly present in background soils due to deposition and/or residues from other man-made source/activities including the combustion of organic materials, fuel residues, and the use of asphalt paving and roofing material. The site maximum concentration of benzo(a)anthracene (368 µg/kg) is less than the upper end of the background range (550 µg/kg). Background ranges are not available for dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene. Site maximum concentrations of benzo(a)pyrene (486 µg/kg) and benzo(b)fluoranthene (297 µg/kg) are slightly higher than the upper end of their respective background ranges (410 µg/kg for benzo(a)pyrene and 297 µg/kg for benzo(b)fluoranthene) but the overall range of detection for each of the detected PAHs is similar to the background concentrations for these compounds.

PAHs in site soil are localized in the vicinity of boring location SB10 and test pit location TP7. Residual PAH concentrations are likely a result of residual tar-like material present at the Site.

Six VOCs were detected in the soil samples – acetone, ethylbenzene, styrene, tetrachloroethene (PCE), trichloroethene (TCE), and total xylenes. Ethylbenzene, styrene, PCE, TCE, and total xylenes were only detected at one location, TP24. Analytical results reveal that none of these VOCs exceeded the residential and industrial direct contact screening levels.

PCBs were not detected in Site 9 soils.

Groundwater

Groundwater samples were collected from MW1 through MW3 in January 2008, MW1 through MW6 in July 2009, and MW4 through MW6 in November 2009. The groundwater samples from the January 2008 sampling event were analyzed for the following parameters; VOCs, SVOCs, pesticides, PCBs, and metals. Due to the lack of pesticides and PCBs in the samples, these parameters were not analyzed in the additional sampling events. Groundwater sampling results were compared to 2009 USEPA RSLs for Tap Water, Maximum Contaminant Levels (MCLs), and 2004 VDEQ Groundwater Quality Standards (VAGQS).

Aluminum, calcium, iron, manganese, and sodium were detected in the groundwater samples. None of the detected metals exceeded their respective screening levels. Calcium and sodium are considered essential nutrients, and screening values are not available for these constituents. The results of the metals analyses are discussed below:

- Total aluminum was detected in 4 of the 12 groundwater samples with the maximum concentrations of 1,230 micrograms per liter (µg/L) detected at MW6. Aluminum concentrations did not exceed the screening level 36,500 µg/L.
- Total iron was detected in 9 of 12 groundwater samples with the maximum concentration of 3,200 µg/L detected at MW2. Iron concentrations did not exceed the screening level of 25,600 µg/L.
- Manganese was detected in 5 of 12 groundwater samples with a maximum concentration of 39 µg/L detected at MW4. The manganese concentrations did not exceed the screening level of 876 µg/L.

One SVOC was detected in Site 9 groundwater. Bis(2-ethylhexyl)phthalate was detected in three of the twelve groundwater samples at concentrations ranging from 2.6 to 6.1 µg/L. One sample collected from MW4 in November 2009 exceeded the screening level of 4.8 µg/L. Note that phthalate esters including bis(2-ethylhexyl)phthalate are commonly used in laboratories. Bis(2-ethylhexyl)phthalate was not detected in the duplicate sample collected from MW4 in November 2009. The presence of bis(2-ethylhexyl)phthalate in groundwater is likely a result of laboratory contamination.

The VOCs in groundwater (chloroform, PCE, and TCE) were detected in at least one groundwater sample. Chloroform and PCE were detected at concentrations exceeding the groundwater screening levels.

- Chloroform was detected only in two samples collected at MW6. Chloroform was detected at MW6 at 0.48 µg/L in July 2009 and at 0.49 µg/L in November 2009. Both detected concentrations exceeded the screening level of 0.193 µg/L.
- PCE was detected in 10 of the 12 groundwater samples at concentrations ranging from 1.6 µg/L to 17.3 µg/L. All detected concentrations of PCE exceeded the screening level of 0.108 µg/L. PCE was detected at all monitoring wells with the exception of MW2. The highest concentrations were observed at MW1 and MW5 with the maximum at MW1 in 2008. The MCL for PCE is 5 µg/L. PCE exceeded the MCL of 5 µg/L at well locations MW1 and MW5. Note that MW1 is located upgradient of Site 9 and well MW5 is directly downgradient of MW1.
- TCE was detected in one sample collected from MW5 at a concentration of 0.88 µg/L at MW5. The detected concentration does not exceed the screening level of 2 µg/L.

Sediment

Three sediment samples were collected from the intermittent streams adjacent to the site during the January 2008 field investigation. Sediment sample results were compared to USEPA RSLs for residential soil and USEPA Region III Biological Technical Assistance Group (BTAG) Sediment Screening Benchmarks.

Seven metals were detected in the sediment samples, with all of the maximum concentrations detected in SE1. Of the seven detected metals, vanadium was the only chemical detected at concentrations exceeding residential direct contact screening levels. No metals were detected in sediment samples at concentrations exceeding ecological-based screening levels. Currently, no human-health screening levels exist for sediment exposure; therefore, the concentrations were compared to soil screening levels. Vanadium was detected at SE1 at a concentration of 7.9 mg/kg, which exceeded the residential direct contact screening level of 0.55 mg/kg. As previously mentioned, vanadium was detected in site soil samples at concentrations ranging from 7.6 to 16.8 mg/kg, which is consistent with the background range (3.5 to 28.5 mg/kg) of vanadium in surface soils. The presence of vanadium in sediment adjacent to the Site is likely a result of the background concentrations of vanadium in soil at the Site and other areas of WFF that discharge to the intermittent tributary.

Pesticides, DDD, DDE, and DDT, were detected in the sediment samples, with all of the maximum concentrations detected at location SE1. DDD was detected at a range of 1.9 to 5.6 µg/kg; DDE was detected at a range of 1.8 to 3.1 µg/kg; and DDT was detected at one location at 3.3 µg/kg. DDD and DDE were detected at concentrations exceeding the ecological-based screening levels. No pesticides were detected in sediment samples at concentrations exceeding residential direct contact screening levels. The background range for DDD in soil is 5.7 to 5,000 µg/kg. Residual levels of pesticides present in sediment are likely a result of former pest control at WFF.

Three PAHs (fluoranthene, phenanthrene, and pyrene) were detected in the sediment samples, with all of the maximum concentrations detected at location SE2. Fluoranthene was detected at a range of 27.9 to 39.8 µg/kg; phenanthrene was detected at a concentration of 25 µg/kg; and pyrene was detected at a range of 23.1 to 33.8 µg/kg. The presence of low levels of PAHs in the sediment may be attributed to silt and soil particles transported from elsewhere on WFF via stormwater runoff to the intermittent tributary. However, none of the detected PAH concentrations in sediment exceeded the residential direct contact or ecological-based screening levels.

Two VOCs (acetone and carbon disulfide) were detected in the sediment samples with the maximum concentrations detected at location SE1. Acetone was detected at SE1 at a concentration of 8.5 µg/kg which is below screening levels. Carbon disulfide was detected only at SE1 at a concentration of 7.8 µg/kg, which is below the residential direct contact based screening level. Carbon disulfide was not detected in any of the site soil samples. The presence of carbon disulfide in sediment is likely a result of other areas of WFF that discharge to the intermittent tributary.

PCBs were not detected in sediment samples.

Surface Water

Three surface water samples were collected during the January 2008 field investigation. Surface water results were compared to USEPA Region III BTAG Freshwater Screening Benchmarks and VDEQ Water Quality Standards.

Numerous metals, including aluminum, calcium, iron, lead, magnesium, manganese, and sodium were detected in the surface water samples. Of the detected metals, total aluminum, iron, lead, and manganese concentrations exceeded surface water screening levels:

- Total aluminum was detected in one surface water sample, SW2, at a concentration of 1 mg/L. The screening level for total aluminum is 0.087 mg/L. Dissolved aluminum was not detected in any of the surface water samples.
- Total iron was detected in all three surface water samples at concentrations ranging from 0.7 mg/L at location SW3 to 6.27 mg/L at location SW1. The screening level for total iron is 0.3 mg/L. Dissolved iron was detected at all three locations at concentrations ranging from 0.233 to 1.99 mg/L.
- Total lead was detected in one surface water sample, SW2, at a concentration of 0.0033 mg/L. The screening level for total lead is 0.0025 mg/L. Dissolved lead was not detected in any of the surface water samples.
- Total manganese was detected in all three surface water samples at concentrations ranging from 0.0641 mg/L at the SW3 location to 0.205 mg/L at SW1. The screening level for total manganese

is 0.12 mg/L. Dissolved manganese was detected in all three surface water samples at concentrations ranging from 0.0616 mg/L at the SW3 location to 0.196 mg/L at SW1.

Dissolved aluminum and lead were not detected in surface water samples indicating that the presence of total aluminum and lead in surface water may be attributable to suspended solids present in the samples. Dissolved iron and manganese were detected in surface water samples. Metals concentrations in surface water may be associated with the migration of sediment-laden stormwater from various areas of WFF discharged through the outfalls to the intermittent stream.

The VOCs 1,2-dichloroethene (1,2-DCE), cis-1,2-dichloroethene (cis-1,2-DCE), PCE, and TCE were detected in the surface water samples collected from the intermittent tributary. None of the detected concentrations exceeded the surface water screening levels. Specific results are as follows:

- 1,2-DCE was detected at SW3 at a concentration of 0.51 µg/L, which is below the screening level of 590 µg/L.
- Cis-1,2-DCE was detected at SW3 at a concentration of 0.51 µg/L, which is below the screening level of 590 µg/L.
- PCE was detected at a range of an estimated 0.29 µg/L at SW2 to 1.4 µg/L at SW3. Both concentrations are below the screening level of 89 µg/L.
- TCE was detected at SW2 at a concentration of 0.54 µg/L, which is below the screening level of 21 µg/L.

The presence of VOCs in surface water indicates a discharge of groundwater to the surface water body. As stated in the Site 9 RI, a source of chlorinated VOCs may be present at a location upgradient of Site 9 (Weston, 2013a). A separate investigation is being conducted to evaluate the source of the VOC contamination in groundwater.

SVOCs, pesticides, and PCBs were not detected in surface water samples.

2.5.5 Fate and Transport

Potential sources of contamination include several areas within the tree line of Site 9 where severely weathered and deteriorated drums were observed. The wooded area also contained many unnatural earthen mounds, possibly suggesting the presence of buried drums. Some contaminants at the site are likely the result of the historical use of pesticides (e.g., DDT) or accumulation of stormwater runoff from multiple sources. The use of DDT as a pesticide was widespread for nearly 40 years until it was banned in 1972. Because of the low chemical reactivity, resistance to oxidation, and resistance to other degenerative processes, residues of these compounds have been shown to be persistent in the environment. Further, these compounds generally are not soluble in water but can accumulate in the tissues of organisms that live in the water. PAHs may be derived from a number of sources, including tar, asphalt, fuel residue, and the combustion of organic materials. PAHs have a strong tendency to bind to sediment particles rather

than dissolve in water, therefore, when PAH residues enter a body of water, they tend to accumulate in sediments (Lindsey et al., 1998).

A source of chlorinated VOCs may be present at an upgradient location to Site 9. This potential source of VOC contamination may impact Site 9 groundwater and resultant surface water where groundwater may be discharging to the intermittent stream. An investigation is being conducted to evaluate the source of VOC contamination in groundwater. The chlorinated VOCs detected in various media are highly mobile in groundwater and surface water environments.

2.6 CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

Currently, WFF is used as a launch facility and airport. Site personnel indicate that there are currently no plans to change the land use from industrial use or to close the facility. Further, closure of the facility is unlikely based on reasons related to orbital trajectory and economies that can be achieved from launches at the WFF latitude, but not at other latitudes.

Site 9 is northwest of active runways (Runway 10-28 and Runway 17-35). The Site is vacant and is not currently being used by NASA for any purpose. Access is strictly controlled by personnel in the Air Traffic Control Tower who monitor activities in the vicinity of the airfield. Only facility employees involved with mission related activities such as maintenance and grounds-keeping are expected to frequent Site 9. In addition, security personnel routinely patrol the area.

It is likely that Site 9 will remain vacant and unused by NASA due to its location near active runways and well within both noise hazard and airfield crash pattern areas. However, given its zoning, it is possible that the area can be commercially developed in the future. It is also conservatively assumed that Site 9 could be developed at some point in the future for residential purposes. This is considered highly unlikely given the location of the Site (adjacent to active runways), the current uses of the Site, its surroundings, and the likelihood that the use of the area will not change.

In addition, there are no current or future plans for groundwater at Site 9. Little Mosquito Creek is not used as a drinking water source because of brackish conditions. It is assumed that the creek could be used by individuals for recreational purposes (e.g., wading, fishing, and crabbing). Water supply wells for the Town of Chincoteague and NASA are located on the Main Base over 3,000 feet from Site 9. All of the NASA supply wells and four of seven active Town of Chincoteague supply wells withdraw water from the Yorktown aquifer. The remaining three active Town of Chincoteague supply wells withdraw water from the Columbia aquifer.

2.7 SUMMARY OF SITE RISKS

2.7.1 Summary of Human Health Risk Assessment

The baseline human health risk assessment (BHHRA) conducted in the 2013 RI evaluated potential risks from contaminants in soil, groundwater, sediment, and surface water to the current / future older child trespasser, future commercial / industrial workers, future construction workers, future age-adjusted resident and the future adult and child residents (Weston, 2013a). The risk summary from the 2013 RI is presented in Table 2-1. However, the BHHRA conducted in the RI did not account for mutagenic effects. Therefore, the risks for exposure were recalculated using the updated criteria. The projected carcinogenic health risks for the current / future older child trespasser, future commercial / industrial workers, future construction workers, and future adult and child resident are within or below the USEPA acceptable risk range (1E-04 to 1E-06). Similarly, all noncancer health effects were below the USEPA hazard index (HI) of 1 for all of these populations. According to the 2013 RI, the site risks to the future age-adjusted resident and future child resident were above the USEPA risk threshold; however, the updated risk assessment, summarized in Sections 2.7.1.3 and 2.7.1.4, demonstrates that cancer and non-cancer risks are within acceptable risks. Details of the BHHRA conducted in the 2013 RI including calculations and comparisons to background may be found in the Site 9 RI Report (Weston, 2013a).

2.7.1.1 Identification of Chemicals of Potential Concern

Table 2-2 presents the chemicals of potential concern (COPCs), the frequency of detection, screening values, maximum concentration detected, and exposure point concentrations for each of the COPCs detected in soil, groundwater, sediment, and surface water and how the exposure point concentration was derived. The contaminant was selected as a COPC if the maximum detection exceeded the appropriate risk based concentration (RBC). The exposure point concentration is the concentration that was used to estimate the exposure and risk from each COPC.

2.7.1.2 Exposure Assessment

This section presents a summary of the exposure assessment detailed in the RI Report (Weston, 2013a). The exposure assessment defines and evaluates the type and magnitude of human exposure to the chemicals present at or migrating from a site. The exposure assessment is designed to depict the physical setting of the site, to identify potentially exposed populations, and to estimate chemical intakes under the identified exposure scenarios. Actual or potential exposures are based on the most likely pathways of contaminant release and transport, as well as human activity patterns. A complete exposure pathway has the following three components: a source of chemicals that can be released into the environment, a route of contaminant transport through an environmental medium, and an exposure or contact point for a human receptor.

The compilation of contaminant sources, likely exposure pathways, and receptors at Site 9 are depicted in the CSM (Figure 2-6). Potential receptors include current / future older child trespasser, future commercial / industrial workers, future construction workers, future age-adjusted resident and the future adult and child residents. It was conservatively assumed that the site could be developed for residential purposes in the future. Thus, hypothetical future residential scenario was evaluated.

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 (Weston, 2013a).

2.7.1.3 Toxicity Assessment

Toxicity criteria utilized in the BHHRA conducted in the 2013 RI are presented in Tables 2-3A, 2-4A, 2-5A, and 2-6A. The risks for soil presented in the 2013 RI did not account for mutagenic effects. Therefore, the risks for exposures to soil were recalculated using updated toxicity criteria. Tables 2-3B, 2-4B, 2-5B, and 2-6B present the toxicity criteria utilized in the updated risk calculations.

Tables 2-3A/B and 2-4A/B provide carcinogenic risk information which is relevant to the COPCs in soil, surface water, sediment, and groundwater. The oral cancer slope factors (CSF) and inhalation unit risks (IUR) used for each compound, and the source of the data, are provided in the attached tables. As indicated in Tables 2-3A/B and 2-4A/B, some compounds are not considered carcinogenic or lack sufficient toxicity information to support the development of specific oral or inhalation toxicity criteria (noted as NA in the tables). At this time, slope factors are not available for the dermal route of exposure. Thus, the dermal slope factor used in the assessment have been extrapolated from oral values. An adjustment factor is sometimes applied and is dependent upon how well the chemical is absorbed via the oral route. Adjustments are particularly important for chemicals with less than 50% absorption via the ingestion route. Adjustment factors applied for the chemicals evaluated at this site are provided in Tables 2-3A/B. For those compounds where an adjustment is not necessary, the factor is noted as 1.0 in the attached table and the oral slope factor was used as the dermal carcinogenic slope factors.

Tables 2-5A/B and 2-6A/B provide noncarcinogenic risk information which is relevant to the COPCs in soil, surface water, sediment, and groundwater. The oral reference doses (RfD) applied to the Site 9 contaminants, and the source of the toxicity data, are provided in Tables 2-5A/B. As was the case for the carcinogenic data, dermal RfDs can be extrapolated from the oral RfDs applying an adjustment factor as appropriate. Adjustment factors applied to the COPCs identified at Site 9 are shown in Tables 2-5A/B. The primary target organ affected by each COPC, if available for chronic and subchronic animal studies, is provided in Tables 2-5A/B.

Site 9 COPCs have toxicity data indicating a potential for adverse noncarcinogenic health effects on humans by the inhalation pathway. The inhalation reference concentration (RfC) and source of the toxicity

data, for each applicable compound is shown in Tables 2-6A/B. These tables also identify the primary target organs affected by each COPC as applicable.

2.7.1.4 Human Health Risk Characterization

For carcinogens, risks are generally expressed as the incremental possibility of an individual developing cancer over a lifetime of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

$$Risk = CDI \times SF$$

Where: Risk = a probability (e.g., 2.0E-05) of an individual developing cancer (unit less)

CDI = chronic daily intake averaged over 70 years (mg/kg/day)

SF = slope factor, expressed as $(mg/kg/day)^{-1}$

These risks are probabilities that are usually expressed in scientific notation (e.g., 1.0E-06). An excess lifetime cancer risk of 1.0E-06 indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This risk is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual developing cancer from all other causes has been estimated to be as high as one in three. The USEPA's generally acceptable risk range for site-related exposure is 10E-4 to 10E-6, or an excess lifetime cancer risk of 1 in 10,000 to 1 in 1,000,000.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with an RfD derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a HI. An HI of less than one indicates that a receptor's dose of a single contaminant is less than the RfD and that toxic noncarcinogenic effects from that chemical are unlikely. The HI is generated by adding the HIs for all COCs that affect the same target organ (e.g., liver). An HI of less than one indicates that, based on the sum of all HIs from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI greater than one indicates that site-related exposures may present a risk to human health.

The HI is calculated as follows:

$$Noncancer\ HI = CDI/RfD$$

Where: CDI = chronic daily intake

RfD = reference dose

CDI and RfD are expressed in the same units (e.g., mg/kg/day) and represent the same exposure period (i.e., chronic, subchronic, or short-term).

Chemicals of Concern

A chemical was retained as a COC if the total Incremental Lifetime Cancer Risk (ILCR) for a medium exceeded 1x10-4 and the chemical specific ILCR exceeded 1x10-6 or if the total HI on a target organ basis exceeded 1 and the chemical specific HI exceeded 0.1. The carcinogenic trigger represents the summed risks to a receptor considering all pathways, media, and routes per land use scenario. The HI represents the total of the Hazard Quotients (HQs) of all COPCs in all pathways, media, and routes to which the receptor is exposed. Chemicals are not considered COCs if their individual carcinogenic risk contribution is less than 1E-06 and their noncarcinogenic HQ is less than 0.1. COCs were identified for the future age-adjusted resident (Tables 2-7A and 2-7BA) and future child resident (Table 2-8A and 2-8B).

The primary risk driver for soil is vanadium. PCE was identified as a COC in groundwater. There were no primary risk drivers for sediment or surface water.

Future Age-adjusted Resident

The carcinogenic risk calculated in the 2013 RI for the future age-adjusted resident is presented in Table 2-7A.

Risks were recalculated to account for mutagenic carcinogens because age-dependent adjustment factors (ADAFs) were not applied in the 2013 RI. In addition, updated toxicity criteria and exposure assumptions were used in these calculations. The recalculated carcinogenic risks for the future age-adjusted resident are presented in Table 2-7B. The total carcinogenic risk for this receptor is estimated to be 1E-05, which is less than the total risk calculated in the 2013 RI (1E-04). The carcinogenic risk is estimated at 9E-06 in soil and 2E-06 in groundwater. Benzo(a)pyrene and arsenic in soil remain as primary risk drivers. The recalculated carcinogenic risk for dibenzo(a,h)anthracene is 6E-07 and is no longer considered a contributing COC in soil for this receptor. The recalculated carcinogenic risk for PCE is 4E-07 and no longer considered a contributing COC in groundwater for this receptor.

Future Child Resident

The noncarcinogenic risk calculated in the 2013 RI for the future child resident is presented in Table 2-8A.

Risks were recalculated to account for updated toxicity criteria and exposure assumptions. The recalculated risk for the future child resident is presented in Table 2-8B. The total non-carcinogenic risk is estimated to be 0.72, which is less than the HQ of 6.0 calculated in the 2013 RI. During the 2013 RI risk calculations, vanadium was the primary risk driver (5.0) through ingestion and dermal contact of soil. The recalculated risk for vanadium through this pathway is 7E-02 and no longer considered a contributing COC through ingestion and dermal contact of soil.

Uncertainty Analysis

Vanadium in surface and subsurface soils for Site 9 is within the background range. The range of Site 9 vanadium levels is 7.6 to 16.8 mg/kg, and the background range is 3.5 to 31.1 mg/kg. Therefore, the elevated HQ for exposure to vanadium-containing soils is reflective of background exposure.

The risks and HIs associated with the future residential scenarios at Site 9 may result in a site risk that is biased high. Although it is possible that the Site could be developed for residential use in the future, it is not likely. Additionally, groundwater is not currently used for potable purposes and will likely not be used as such in the future. The calculated residential risks are primarily driven by VOC (PCE) exposure through groundwater ingestion, dermal, and inhalation pathways. The highest levels of VOC contamination were identified upgradient of Site 9 and are not site related (Weston, 2013a). A separate investigation is being conducted to evaluate the source of the VOC contamination in groundwater.

2.7.2 Summary of the Ecological Risk Assessment

The ecological risk assessment (ERA) was performed to evaluate the actual or potential ecological effects from exposure to the contaminants at Site 9. This multi-pathway analysis was based on reasonable, protective assumptions about the potential for ecological receptors to be exposed and/or adversely affected by the exposure to chemicals. Details may be found in the RI Report (Weston, 2013a). The ERA for Site 9 included the following steps of the ERA process:

- Step 1 – Screening-level problem formulation and ecological effects evaluation.
- Step 2 – Screening-level exposure estimate and risk calculation.
- Step 3 – Baseline risk assessment problem formulation.
- Step 4 – Study design and data quality objective process.
- Step 5 – Field verification of sampling design.
- Step 6 – Site investigation and analysis phase.
- Step 7 – Risk characterization.
- Step 8 – Risk management.

2.7.2.1 Identification of Chemicals of Potential Ecological Concern

To establish the list of chemicals of potential ecological concern (COPEC), USEPA Region III BTAG Screening Benchmarks were used to screen soil, sediment, and surface water for ecological risks. If the BTAG tables did not provide a value for a detected compound, bench marks were obtained from various sources (Ecological Soil Screening Levels [ECO-SSL], Oak Ridge National Laboratory (ORNL), Interim sediment quality guideline, probably effect level, and VDEQ Water Quality for Freshwater Acute and Chronic Aquatic Life Standards). The final list of COPEC for which food chain modeling was conducted consisted of constituents meeting the following criteria:

- Constituents whose maximum concentration exceeded the ecological benchmark.
- Constituents for which ecological benchmarks were not available.
- Bioaccumulative compounds.

Two different risk scenarios were addressed by modeling. The first was highly conservative, and evaluated risks using a no observed adverse effect level (NOAEL) as a toxicity reference value (TRV), or measure of toxicological effect. The second scenario was more realistic as the lowest observable adverse effect level (LOAEL) was used as a measure of toxicological effect for comparison with the dose under this scenario.

There is a potential for adverse effects to wildlife as a result of contamination in the terrestrial and aquatic systems. Because of the biomagnification potential associated with some of the COPEC, it was determined that representative, upper and intermediate trophic level receptors needed to be evaluated. For terrestrial evaluation, the American robin, short-tailed shrew, red fox, and red-tailed hawk were selected as target receptors. For aquatic, the mink, raccoon, and great-blue heron were selected as target receptors. The food chain HQ was calculated for each of these receptors.

Site 9 Soil

Table 2-9 presents the Site 9 occurrence, distribution, and selection of COPEC and Table 2-10 presents the HQs for terrestrial receptors. Results indicate the potential for ecological risks to American robins and short-tailed shrews from ingestion of earthworms contaminated with site soils. HQs greater than 1.0 calculated using the NOAEL as a toxicological reference were noted for the American robin from ingestion of earthworms contaminated with DDD (HQ = 1.9), DDE (HQ = 68), DDT (HQ = 5.2), aluminum (HQ = 2.4), chromium (HQ = 13), and mercury (HQ = 16). HQs greater than 1.0 calculated using the LOAEL as toxicological reference were noted for the American robin from ingestion of earthworms contaminated with DDE (HQ = 7.3), aluminum (HQ = 2.4), chromium (HQ = 2.5), and mercury (HQ = 1.5). HQs greater than 1.0 calculated using the NOAEL as toxicological reference were noted for the short-tailed shrew from aluminum (HQ = 17). HQs greater than 1.0 calculated using the LOAEL as a toxicological reference were noted for the short-tailed shrew from aluminum (HQ = 1.7).

Concentrations of DDE, DDT, aluminum, chromium, and mercury in the soils at Site 9 are within the range of the concentrations detected in the background soil investigation (Tetra Tech, 2004). A background range is not available for DDD.

Aquatic Ecosystems

Table 2-11 and Table 2-12 presents the occurrence, distribution, and selection of COPEC for surface water and sediment. Table 2-13 presents the HQs for aquatic receptors. No HQs greater than 1.0 were noted for the receptors evaluated.

2.7.2.2 Exposure Assessment

This section presents a summary of exposure assessment detailed in the Site 9 RI Report (Weston, 2013a). The habitat, contaminants present, migration pathways, and the routes by which receptors may be exposed to chemicals were defined and evaluated as part of the ERA. Site 9 consists of a disturbed area as switchgrass, broomsedge, bush clover (*Lespedeza* sp), ragweed (*Ambrosia artemesifolia*), goldenrods (*Solidago* spp.) and others. It is adjacent to a forested area to the north dominated by an overstory of sweet gum (*Liquidambar styraciflua*), red maple (*Acer rebrum*), black cherry (*Prunus serotina*) and loblolly pine, and understories of greenbrier (*Smilax rotundifolia*), wax myrtle (*Morella cerfera*), and ostrich fern (*Matteuccia struthiopteris*). This type of habitat is common in the forested floodplains of coastal northern Virginia.

The largest parcel of natural terrestrial habitat at WFF, a mixed deciduous/pine forest which borders Little Mosquito Creek, is adjacent to and West of Site 9. The forest consists of a dense canopied stand of loblolly and Virginia pine (P. *taeda and Pinus virginiana*), willow and black oak (*Quercus phellos* and *Quercus velutina*), sweetgum, and red maple. Shrub and herb layers are sparse throughout the forest, except in the occasional open areas. In the shrubby areas, spicebush (*Lindera benzoin*), Tartarian honeysuckle (*Lonicera tatarica*), and principal canopy trees are found. Bracken (*Pteridium aquilinu*m) and partridgeberry (*Mitchella repens*), as well as unidentified grasses, are found in the forest.

The portion of the unnamed tributary adjacent to the Site is surrounded by freshwater (palustrine) forested wetlands dominated by sweetgum, red maple and occasional loblolly pine. The soil and sediment samples collected during the RI were collected largely within this area.

The unnamed tributary itself receives runoff from the runway, taxiways and ramp areas, and the surrounding vicinity. It is clear on the basis of available information that the upper end of this tributary at the Site is fed primarily by stormwater flow. Site personnel indicated that the flow is intermittent or non-flowing during periods without precipitation. The intermittent stream originates at the discharge points of two permitted outfalls for the WFF stormwater collection network: Outfall 0013 and Outfall 005 (Figure 2-3). The intermittent streams converge west-southwest of Site 9, after which stormwater runoff is conveyed in a northerly direction for approximately 0.3 miles before discharging into Little Mosquito Creek.

The wetlands are tidally-influenced and primarily herbaceous. Principal species include Spartina grasses (*Spartina alterniflora, S. patens,* and *S. cynosuroides*) and threesquare (*Scirpus pungent*). In the delta where the drainage ditch flows into Little Mosquito Creek, there is a moderately large area of tidally-influenced wetland scrub/shrub habitat. This habitat is dominated by wax myrtle (*Myrica cerifera*), buttonbush (*Cephalanthus occidentalis*), and groundsel bush (*Baccharia halimifolia*). Some small trees are also found scattered in this area – primarily black willow (*Salix nigra*) and red maple. Cinnamon fern (*Osmunda cinnamomea*) and royal fern (*Osmunda regalis*) are the primary herbs found in the scrub/shrub habitat.

A very narrow margin of deciduous forested wetland exists along most of the length of the unnamed tributary of the scrub/shrub area. These wetlands are not tidally-influenced and are dominated by small trees. The primary species found there are red maple, black willow, and sweetgum. Spicebush is the most commonly found shrub, with sensitive fern (*Onoclea sensibilis*), royal fern, and cinnamon fern being the most common herbs.

The USEPA recommends that receptor species be selected to represent a specific trophic level or feeding guild for assessing local food chain effects. This selection process was used to develop and refine a conceptual food chain model which incorporates a variety of ecological receptors deemed representative of plant and animal communities associated with Site 9. Figures 2-6 and 2-7 present the Ecological CSM for the terrestrial and aquatic ecosystem.

Site 9 is located within the Little Mosquito Creek Conservation Site. Of the special status species lists resulting from searches, only the bald eagle is known to have been observed and the species has nested at one location on Little Mosquito Creek.

Table 2-14 presents the ecological exposure pathways of concern as well as assessment and measurement endpoints of concern. The assessment endpoints have been selected to address both the potential direct and indirect impacts resulting from exposure to COPEC. The receptors evaluated for Site 9 terrestrial ecosystem are vegetation, soil fauna, insectivorous birds and mammals, and carnivorous mammals. The receptors evaluated for the aquatic ecosystem are benthic invertebrates, fish, and piscivorous mammals and birds.

2.7.2.3 Ecological Effects Assessment

The assessment methods used in the ERA considered only comparisons of media concentrations, comparisons of tissue residues, or modeled doses with benchmark values and reference toxicity values. The selection of receptors for actual modeling took into account available site-specific information already collected at nearby Sites 14 and 15 (Figure 2-2). Because fish live their entire life in the water column and would be exposed to contaminants for a longer duration, they are conservative receptors for evaluating the unnamed tributary since the upper portion of it adjacent to Site 9 is apparently dry for part of the year. While the CSM indicated that frogs are receptors that potentially could be at risk, a separate analysis was not undertaken for frogs due to lack of tissue data, and the fact that the analysis using fish data should be adequately protective of frogs as well. Uptake to killifish was modeled with the site-specific data from Sites 14 and 15.

The food chain ingestion models employed to assess potential risks to piscivorous birds and mammals used killifish as the exclusive food item. The concentration in the fish tissue was modeled using site-specific data collected previously during the Sites 14 and 15 RI (Weston, 2013b). Maximum concentrations of analytes detected in killifish collected in Little Mosquito Creek were divided by maximum sediment concentrations of the same analytes to determine the fraction of contaminants potentially accumulating into

fish tissue, or bioaccumulation factor (BAF). The fish tissue BAF was then multiplied by the maximum concentration of analytes detected in sediment in the three samples collected adjacent to Site 9. The analysis limited those analytes that were COPECs, that is, that were considered bioaccumulative in sediment above screening benchmarks. The resultant BAFs by analyte that were used to estimate tissue concentrations of killifish potentially entering the upper portion of the unnamed tributary can be found in the Site 9 RI (Weston, 2013a)

Assessment Endpoints

Terrestrial Ecosystem

Maximum concentrations of metals (aluminum, chromium, iron, lead, manganese, mercury, nickel, vanadium, and zinc) as well as pesticides (DDE and DDT), and PAHs (acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, and pyrene) exceeded soil ecological benchmarks. Of these, benzo(a)anthracene, benzo(b)flouranthene, and pyrene exceeded WFF background soil concentrations. Background ranges were not available for acenaphthylene, anthracene, benzo(g,h,i)perylene, and indeno(1,2,3-cd)pyrene. All chemicals detected above background ranges, chemicals for which no benchmarks were available, and bioaccumulative chemicals (mercury and DDT) were retained and were modeled for potential food chain impacts.

Food chain HQ modeling for COPEC indicated that the American robin and short-tailed shrew would be at risk from ingestion of soil invertebrates. Modeling using the NOAEL as a toxicological reference indicated risks from robins ingesting soil invertebrates contaminated with DDD, DDE, DDT, aluminum, chromium, and mercury. Modeling using the LOAEL as a toxicological reference indicated risks from robins ingesting soil invertebrates contaminated with DDE, aluminum, chromium, and mercury. Modeling using the NOAEL and LOAEL indicated risks to shrews from aluminum. Concentrations of DDE, DDT, aluminum, chromium, and mercury in soils at Site 9 are within range of the concentrations detected in the background investigation (Tetra Tech, 2004). A background range is not available for DDD.

Remaining receptors (red fox and red-tailed hawk) modeled did not show evidence of potential ecological risks from soil.

Aquatic Ecosystem

Concentrations of aluminum, iron, lead, and manganese in the three surface water samples collected from within the unnamed tributary of Little Mosquito Creek exceeded their respective USEPA Region III BTAG freshwater Ecological benchmarks and thus represent a potential contamination source to Little Mosquito Creek. However, surface water samples collected from Little Mosquito Creek as part of the Sites 14 and 15 RI did not show these metals presented a risk to ecological receptors. Thus, the levels detected at Site 9 are not likely to negatively impact the estuarine ecosystem of the creek.

Groundwater concentrations of metals (aluminum and iron) collected from the six Site 9 wells (MW1 through MW6) exceeded USEPA Region III BTAG freshwater surface water screening benchmarks. However, groundwater concentrations fell within the range of background groundwater concentrations detected in the background investigation. As a result, it is unlikely that any surface water impacts are attributable to groundwater from Site 9 activities.

DDD, DDE, and DDT were detected in the sediment within the unnamed tributary to Little Mosquito Creek at concentrations that exceeded ecological screening benchmarks. Although DDT, its breakdown products, and several metals were detected in soil at the Site, there is no evidence from the three sediment samples collected in the current investigation of the Site 9 area that this contamination originated specifically from Site 9. In addition, stormwater, which may potentially contain residual pesticide from historic facility-wide application could be transported to sediment within the unnamed tributary to Little Mosquito Creek via stormwater outfalls upgradient of Site 9.

Modeling undertaken to evaluate whether fish potentially entering the upper portion of the unnamed tributary to Little Mosquito Creek could be at risk indicated that modeled tissue concentrations would not exceed toxicological effects levels. Food chain HQ modeling indicated that no HQs greater than 1.0 were noted for any receptors evaluated.

2.7.2.4 Ecological Risk Characterization

Food chain modeling indicated that the American robin and short-tailed shrew would be at risk from ingestion of soil invertebrates; however, all COPECs (various pesticides and metals) detected at Site 9 were at concentrations consistent with WFF background soil levels. Additionally, PAHs were only detected in 4 of 23 soil samples collected at the site with only three specific samples (surface samples at SB10, TP7, and TP24) exceeding soil ecological screening benchmarks. A summary of comparison of the 13 detected PAHs in soil to WFF background indicated the following: (1) only three PAHs (benzo[a]pyrene, benzo[k]fluoranthene, and pyrene) exceeded WFF background, (2) five PAHs were lower than WFF background, and (3) five PAHs had no background concentrations.

2.7.3 Risk Assessment Conclusion

The BHHRA conducted in the 2013 RI indicated vanadium in surface and subsurface soil contributed to noncancerous risk, but concentrations of vanadium in soil were within the background range. Therefore, the elevated HQ for exposure to vanadium-containing soils is reflective of background exposure. The recalculated risk assessment concluded concentrations of vanadium in surface and subsurface soils no longer contributed to unacceptable risk. This change was due to updates in the toxicity criteria as presented in Table 2-5B. Other contaminants identified as human health risk contributors were found to be not site-related and/or resulted in risks within the acceptable risk range.

Ecological risks identified from metals and pesticides were reflective of background exposure. Based on the low PAH detection frequency, and the few PAHs that exceeded WFF background concentrations, further action at Site 9 is not warranted.

As determined in the 2013 BBHRA, unacceptable human health risks were driven primarily by PCE in groundwater. The recalculated risk assessment concluded that PCE no longer contributed to risk due to changes in toxicity criteria. Groundwater upgradient of Site 9 contained the highest level of PCE which is being addressed through a separate investigation/action.

2.8 DOCUMENTATION OF SIGNIFICANT CHANGES FROM THE PROPOSED PLAN

The PP for Site 9 at NASA WFF, Wallops Island, Virginia was released for public comments on May 25, 2016. The PP identified No Further Action as the preferred alternative for Site 9. No written or verbal comments were submitted during the comment period. It was determined that no significant changes to the remedy, as originally identified in the PP, were necessary or appropriate based on public comments.

3.0 RESPONSIVENESS SUMMARY

In accordance with Sections 113 and 117 of CERCLA, NASA provided a public comment period from May 27, 2016 to June 27, 2016 for the proposed remedial action as described in the PP for the Site. Public input is a key element in the decision-making process.

The PP remains available to the public in the Administrative Record. The RI is also available in the Administrative Record. The Information Repositories for the Administrative Record are maintained by the Eastern Shore Public Library (23610 Front Street, Accomack, Virginia 23301) and the Island Library (4077 Main Street, Chincoteague, Virginia 23336).

Public notices announcing the comment period and availability of documents were placed in the Chincoteague Beacon and Eastern Shore News on May 25, 2016, respectively.

No comments were received by NASA, USEPA, or VDEQ during this public comment period.

On January 22, 2021, the PP was sent electronically to the Catawba Indian Nation, Chickahominy Indian Tribe, Chickahominy Indian Tribe – Eastern Division, Monacan Indian Nation, Nansemond Indian Nation, Pamunkey Indian Tribe, Rappahannock Tribe, and Upper Mattaponi Indian Tribe. Comments were requested by February 21, 2021. Paper copies of the PP were also sent to the Catawba Indian Nation. On February 18, 2021, the Tribal Historic Preservation Officer of the Catawba Indian Nation responded that "the Catawba have no immediate concerns with regard to traditional cultural properties, sacred sites or Native American archeological sites within the boundaries of the proposed project area." No other responses were received during the comment period.

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TABLES

TABLE 2-1

RISK SUMMARY
SITE 9 - DRUM DISPOSAL AREA
NASA WFF, WALLOPS ISLAND VIRGINIA

Exposure Scenario	Site Health Effects	
	ILCR	HI
Current / Future Older Child Trespasser		
Soil	3.E-07	0.20
Sediment	--	0.10
Surface Water	3.E-07	0.0003
Site Total:	5.E-07	0.30
Future Commercial / Industrial Worker		
Soil	2.E-06	0.4
Site Total:	2.E-06	0.4
Future Construction Worker		
Soil	2.E-07	0.7
Groundwater	1.E-07	0.003
Site Total:	4.E-07	0.7
Future Age-adjusted Resident		
Soil	2.E-05	--
Groundwater	**1.E-04**	--
Sediment	--	--
Surface Water	9.E-07	--
Site Total:	**1.E-04**	--
Future Adult Resident		
Soil	5.E-06	0.7
Groundwater	7.E-05	0.2
Sediment	--	0.04
Surface Water	6.E-07	0.0003
Site Total:	8.E-05	0.9
Future Child Resident		
Soil	--	**5.0**
Groundwater	--	0.40
Sediment	--	0.30
Surface Water	--	0.001
Site Total:	--	**6.0**

Notes:

Bold/Shaded areas equal site ILCR greater than 1E-04 or HI greater than 1.0.

ILCR - Incremental Life Cancer Risk.

HI - Hazard Index.

-- - Not calculated. In this medium and reach, there were no COPCs.

TABLE 2-2

SUMMARY OF CHEMICALS OF POTENTIAL CONCERN
SITE 9 - DRUM DISPOSAL AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Exposure Point	Chemical of Potential Concern	Frequency of Detection	Screening Toxicity Value[1] [2]	Maximum Concentration Detected	Exposure Point Concentration	Units	Statistical Measure
Subsurface Soil – ingestion and dermal contact, and inhalation	Benzo(a)pyrene	1/17	1.48E-02 C	4.53E-02	4.53E-02	mg/kg	Maximum[3]
	Aluminum	17/17	7.74E+03 N	1.14E+04	8.26E+03	mg/kg	95% Student's-t UCL[4]
	Arsenic	2/17	3.89E-01 C	2.50E+00	2.50E+00	mg/kg	Maximum[3]
	Chromium	17/17	2.93E-01 C	1.01E+01	8.04E+00	mg/kg	95% Student's-t UCL[4]
	Iron	17/17	5.48E+03 N	6.99E+03	4.22E+03	mg/kg	95% Student's-t UCL[4]
	Vanadium	11/17	5.50E-01 N	1.40E+01	1.02E+01	mg/kg	95% KM (t) UCL[4]
Surface Soils – ingestion, dermal contact, and inhalation	Benzo(a)anthracene	2/12	1.48E-01 C	3.68E-01	3.68E-01	mg/kg	Maximum[3]
	Benzo(a)pyrene	2/12	1.48E-02 C	4.86E-01	4.86E-01	mg/kg	Maximum[3]
	Benzo(b)fluoranthene	2/12	1.48E-01 C	2.97E-01	2.97E-01	mg/kg	Maximum[3]
	Dibenz(a,h)anthracene	2/12	1.48E-02 C	7.00E-02	7.00E-02	mg/kg	Maximum[3]
	Indeno(1,2,3-cd)pyrene	2/12	1.48E-01 C	2.25E-01	2.25E-01	mg/kg	Maximum[3]
	Aluminum	12/12	7.74E+03 N	1.37E+04	9.16E+03	mg/kg	95% Student's-t UCL[4]
	Arsenic	4/12	3.89E-01 C	3.40E+00	2.52E-01	mg/kg	95% KM (t) UCL[4]
	Chromium	12/12	2.93E-01 C	1.23E+01	8.98E+00	mg/kg	95% Approximate Gamma UCL[5]
	Iron	12/12	5.48E+03 N	8.12E+03	5.65E+03	mg/kg	95% Student's-t UCL[4]
	Vanadium	12/12	5.50E-01 N	1.68E+01	1.33E+01	mg/kg	95% Student's-t UCL[4]
Groundwater - ingestion, dermal contact, and inhalation	Bis(2-ethylhexyl)phthalate	3/12	4.80E+00 C	6.10E+00	6.10E+00	µg/L	Maximum[3]
	Chloroform	2/12	1.93E-01 C	4.90E-01	4.90E-01	µg/L	Maximum[3]
	Tetrachloroethene	10/12	1.08E-01 C	1.73E+01	8.66E+00	µg/L	95% KM (t) UCL[4]
	Iron	9/12	2.56E+03 N	3.20E+03	2.48E+03	µg/L	95% KM (Chebyshev) UCL[5]
Sediment - ingestion and dermal contact	Chromium	3/3	2.90E+00 C	7.50E+00	7.50E+00	mg/kg	Maximum[3]
	Vanadium	1/3	5.50E+00 N	7.90E+00	7.90E+00	mg/kg	Maximum[3]
Surface Water - ingestion/ dermal contact	Tetrachloroethene	2/3	1.10E+00 C	1.40E+00	7.90E+00	µg/L	Maximum[3]

TABLE 2-2

SUMMARY OF CHEMICALS OF POTENTIAL CONCERN
SITE 9 - DRUM DISPOSAL AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Notes:

µg/L – micrograms per liter.
C - Cancerous.
mg/kg - milligrams per kilogram.
KM - Kaplan-Meier
N - Noncancerous.
RBC - risk based concentration.
RCRA - Resource Conservation and Recovery Act
THQ - target hazard quotient
TR - target risk
UCL: Upper confidence limit.

(1) Soil and Sediment Screening Toxicity - Region 3 residential soil RBC with a TR of 1E-06 and THQ of 0.1. USEPA has not assigned toxicity values to lead, therefore the RCRA corrective lead level for soil is used.

(2) Groundwater and Surface water Screening Toxicity - Region 3 tap water RBC with a TR of 1E-06 and THQ of 0.1. The Screening Toxicity Value for lead is based on the drinking water action level.

(3) 95% UCL exceeds maximum detected concentration. Therefore, maximum concentration used for Exposure Point Concentration.

(4) Based on ProUCL recommendation, data is normally distributed.

(5) Based on ProUCL recommendation, data is gamma distributed.

TABLE 2-3A

2013 RI CANCER TOXICITY DATA -- ORAL/DERMAL

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal (1)	Absorbed Cancer Slope Factor for Dermal (1)		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date(s) (2) (MM/DD/YYYY)
Benzo[a]anthracene	7.30E-01	1/mg/kg/day	1.00E+00	7.30E-01	1/mg/kg/day	B2	ECAO	RSL Table (12/09)
Benzo[a]pyrene	7.30E+00	1/mg/kg/day	1.00E+00	7.30E+00	1/mg/kg/day	B2	IRIS	4/2/2010
Benzo[b]fluoranthene	7.30E-01	1/mg/kg/day	1.00E+00	7.30E-01	1/mg/kg/day	B2	ECAO	RSL Table (12/09)
Bis(2-ethylhexyl) phthalate	1.40E-02	1/mg/kg/day	1.00E+00	1.40E-02	1/mg/kg/day	B2	IRIS	RSL Table (09/08)
Chloroform	3.10E-02	1/mg/kg/day	1.00E+00	3.10E-02	1/mg/kg/day	B2	Cal EPA	RSL Table (12/09)
Dibenz(a,h)anthracene	7.30E+00	1/mg/kg/day	1.00E+00	7.30E+00	1/mg/kg/day	B2	ECAO	RSL Table (12/09)
Indeno[1,2,3-cd]pyrene	7.30E-01	1/mg/kg/day	1.00E+00	7.30E-01	1/mg/kg/day	B2	ECAO	RSL Table (12/09)
Tetrachloroethene	5.40E-01	1/mg/kg/day	1.00E+00	5.40E-01	1/mg/kg/day	B1	Cal EPA	RSL Table (12/09)
Aluminum, Total	NA	---	---	NA	---	---	---	---
Arsenic, Total	1.50E+00	1/mg/kg/day	1.00E+00	1.50E+00	1/mg/kg/day	A	IRIS	4/2/2010
Chromium, Total	NA	---	---	NA	---	---	---	---
Iron, Total	NA	---	---	NA	---	---	---	---
Vanadium, Total	NA	---	---	NA	---	---	---	---

(1) EPA, 2009b.
(2) Represents date source was searched.

Definitions:
Cal EPA = California Environmental Protection Agency.
ECAO = Environmental Criteria and Assessment Office.
IRIS = Integrated Risk Information System.
NA = Not available.
RSL = Regional screening level.

A - Human carcinogen.
B1 - Probable human carcinogen - indicates that limited human data are available.
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans.

TABLE 2-3B
2017 CANCER TOXICITY DATA - ORAL/DERMAL
SITE 9, WALLOPS FLIGHT FACILITY, VIRGINIA

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal[1]	Absorbed Cancer Slope Factor for Dermal[2]		Weight of Evidence/ Cancer Guideline Description[3]	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Semivolatile Organic Compounds								
Benzo(a)anthracene[4]	1.0E-01	$(mg/kg/day)^{-1}$	1	1.0E-01	$(mg/kg/day)^{-1}$	Carcinogenic to humans	USEPA(1)	7/1993
Benzo(a)pyrene[4]	1.0E+00	$(mg/kg/day)^{-1}$	1	1.0E+00	$(mg/kg/day)^{-1}$	Carcinogenic to humans	IRIS	6/12/2017
Benzo(b)fluoranthene[4]	1.0E-01	$(mg/kg/day)^{-1}$	1	1.0E-01	$(mg/kg/day)^{-1}$	Carcinogenic to humans	USEPA(1)	7/1993
Benzo(k)fluoranthene[4]	1.0E-02	$(mg/kg/day)^{-1}$	1	1.0E-02	$(mg/kg/day)^{-1}$	Carcinogenic to humans	USEPA(1)	7/1993
Dibenzo(a,h)anthracene[4]	1.0E+00	$(mg/kg/day)^{-1}$	1	1.0E+00	$(mg/kg/day)^{-1}$	Carcinogenic to humans	USEPA(1)	7/1993
Indeno(1,2,3-cd)pyrene[4]	1.0E-01	$(mg/kg/day)^{-1}$	1	1.0E-01	$(mg/kg/day)^{-1}$	Carcinogenic to humans	USEPA(1)	7/1993
Inorganics								
Aluminum, Total	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic, Total	1.5E+00	$(mg/kg/day)^{-1}$	1	1.5E+00	$(mg/kg/day)^{-1}$	A (human carcinogen)	IRIS	6/12/2017
Chromium, Total[4,5]	5.0E-01	$(mg/kg/day)^{-1}$	0.025	2.0E+01	$(mg/kg/day)^{-1}$	Carcinogenic potential cannot be determined	Cal EPA	7/29/2011
Iron, Total	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium, Total	NA	NA	NA	NA	NA	NA	NA	NA

Footnotes:

1 - USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

2 - Adjusted cancer slope factor for dermal = Oral cancer slope factor / Oral absorption efficiency for dermal.

3 - Weight of evidence description is the most recent one presented in IRIS.

4 - Carcinogenic PAHs and hexavalent chromium are considered to act via the mutagenic mode of action. These chemicals are evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (March 2005).

5 - Values are for hexavalent chromium.

Definitions:

IRIS = Integrated Risk Information System.

NA = Not Available.

USEPA(1) = USEPA Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons, 1993b, EPA/600/R-93/089.

TABLE 2-4A

2013 RI CANCER TOXICITY DATA -- INHALATION

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor		Weight of Evidence/ Cancer Guideline Description	Unit Risk: Inhalation CSF	
	Value	Units	Value	Units		Source(s)	Date(s) (1) (MM/DD/YYYY)
Benzo[a]anthracene	1.10E-04	1/µg/m3	3.85E-01	1/mg/kg-day	B2	Cal EPA	RSL Table (12/09)
Benzo[a]pyrene	1.10E-03	1/µg/m3	3.85E+00	1/mg/kg-day	B2	Cal EPA	RSL Table (12/09)
Benzo[b]fluoranthene	1.10E-04	1/µg/m3	3.85E-01	1/mg/kg-day	B2	Cal EPA	RSL Table (12/09)
Bis(2-ethylhexyl) phthalate	2.40E-06	1/µg/m3	8.40E-03	1/mg/kg-day	B2	Cal EPA	RSL Table (12/09)
Chloroform	2.30E-05	1/µg/m3	8.05E-02	1/mg/kg-day	B2	IRIS	4/2/2010
Dibenz(a,h)anthracene	1.20E-03	1/µg/m3	4.20E+00	1/mg/kg-day	B2	Cal EPA	RSL Table (12/09)
Indeno[1,2,3-cd]pyrene	1.10E-04	1/µg/m3	3.85E-01	1/mg/kg-day	B2	Cal EPA	----
Tetrachloroethene	5.90E-06	1/µg/m3	2.07E-02	1/mg/kg-day	B1	Cal EPA	RSL Table (12/09)
Aluminum, Total	NA	---	NA	---	---	---	----
Arsenic, Total	4.30E-03	1/µg/m3	1.51E+01	1/mg/kg-day	A	IRIS	4/2/2010
Chromium, Total	NA	---	NA	---	---	---	---
Iron, Total	NA	---	NA	---	---	---	----
Vanadium, Total	NA	---	NA	---	---	---	----

(1) Represents date source was searched.

(2) Naphthalene was used as a surrogate for phenanthrene.

Definitions:

Cal EPA = California Environmental Protection Agency.

IRIS = Integrated Risk Information System.

NA = Not available.

PPRTV = EPA provisional peer-reviewed toxicity value

RSL = Regional Screening Level.

A - Human carcinogen.

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans.

C - Possible human carcinogen.

TABLE 2-4B
2017 CANCER TOXICITY DATA - INHALATION
SITE 9, WALLOPS FLIGHT FACILITY, VIRGINIA

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor[1]		Weight of Evidence/ Cancer Guideline Description[2]	Unit Risk : Inhalation CSF	
	Value	Units	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Semivolatile Organic Compounds							
Benzo(a)anthracene[3]	6.0E-05	$(ug/m^3)^{-1}$	2.1E-01	$(mg/kg/day)^{-1}$	Carcinogenic to humans	USEPA(1)	7/1993
Benzo(a)pyrene[3]	6.0E-04	$(ug/m^3)^{-1}$	2.1E+00	$(mg/kg/day)^{-1}$	Carcinogenic to humans	IRIS	6/12/2017
Benzo(b)fluoranthene[3]	6.0E-05	$(ug/m^3)^{-1}$	2.1E-01	$(mg/kg/day)^{-1}$	Carcinogenic to humans	USEPA(1)	7/1993
Benzo(k)fluoranthene[3]	6.0E-06	$(ug/m^3)^{-1}$	2.1E-02	$(mg/kg/day)^{-1}$	Carcinogenic to humans	USEPA(1)	7/1993
Dibenzo(a,h)anthracene[3]	6.0E-04	$(ug/m^3)^{-1}$	2.1E+00	$(mg/kg/day)^{-1}$	Carcinogenic to humans	USEPA(1)	7/1993
Indeno(1,2,3-cd)pyrene[3]	6.0E-05	$(ug/m^3)^{-1}$	2.1E-01	$(mg/kg/day)^{-1}$	Carcinogenic to humans	USEPA(1)	7/1993
Inorganics							
Aluminum, Total	NA	NA	NA	NA	NA	NA	NA
Arsenic, Total	4.3E-03	$(ug/m^3)^{-1}$	1.5E+01	$(mg/kg/day)^{-1}$	A (Known human carcinogen)	IRIS	6/12/2017
Chromium, Total[3,4]	8.4E-02	$(ug/m^3)^{-1}$	2.9E+02	$(mg/kg/day)^{-1}$	Known/likely human carcinogen	IRIS	6/12/2017
Iron, Total	NA	NA	NA	NA	NA	NA	NA
Vanadium, Total	NA	NA	NA	NA	NA	NA	NA

Footnotes:

1 - Inhalation CSF = Unit Risk * 70 kg / $20m^3$/day.

2 - Weight of evidence description is the most recent one presented in IRIS.

3 - Carcinogenic PAHs and hexavalent chromium are considered to act via the mutagenic mode of action. These chemicals are evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (March 2005).

4 - Values are for hexavalent chromium.

Definitions:

IRIS = Integrated Risk Information System.

NA = Not Available.

USEPA(1) = USEPA Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons, 1993b, EPA/600/R-93/089.

TABLE 2-5A

2013 RI NON-CANCER TOXICITY DATA -- ORAL/DERMAL

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal (1)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD: Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (2) (MM/DD/YYYY)
Benzo[a]anthracene	---	NA	---	---	NA	---	---	---	---	---
Benzo[a]pyrene	---	NA	---	---	NA	---	---	---	---	---
Benzo[b]fluoranthene	---	NA	---	---	NA	---	---	---	---	---
Bis(2-ethylhexyl) phthalate	Chronic	2.00E-02	mg/kg/day	1.00E+00	2.00E-02	mg/kg/day	Liver	1,000	IRIS	4/2/2010
Chloroform	Chronic	1.00E-02	mg/kg/day	1.00E+00	1.00E-02	mg/kg/day	Liver	100	IRIS	4/2/2010
Dibenz(a,h)anthracene	---	NA	---	---	NA	---	---	---	---	---
Indeno[1,2,3-cd]pyrene	---	NA	---	---	NA	---	---	---	---	---
Tetrachloroethene	Chronic	1.00E-02	mg/kg/day	1.00E+00	1.00E-02	mg/kg/day	Liver/Body weight	1,000	IRIS	4/2/2010
Aluminum, Total	Chronic	1.00E+00	mg/kg/day	1.00E+00	1.00E+00	mg/kg/day	CNS	100	PPRTV	RSL Table (12/09)
Arsenic, Total	Chronic	3.00E-04	mg/kg/day	1.00E+00	3.00E-04	mg/kg/day	Skin	3	IRIS	4/2/2010
Chromium, Total	Chronic	1.50E+00	mg/kg/day	1.30E-02	1.95E-02	mg/kg/day	NOEL	1,000	IRIS	4/2/2010
Iron, Total	Chronic	7.00E-01	mg/kg/day	1.00E+00	7.00E-01	mg/kg/day	Gastrointestinal	1.5	PPRTV	RSL Table (12/09)
Vanadium, Total	Chronic	7.00E-05	mg/kg/day	2.60E-02	1.82E-06	mg/kg/day	Hair	100	PPRTV	RSL Table (12/09)

(1) EPA, 2009b.

(2) Represents date source was searched.

Definitions: CNS=Central nervous system.

IRIS=Integrated Risk Information System.

NA=Not available.

PPRTV = EPA provisional peer-reviewed toxicity value.

RSL = Regional Screening Level.

TABLE 2-5B
2017 NON-CANCER TOXICITY DATA - ORAL/DERMAL
SITE 9, WALLOPS FLIGHT FACILITY, VIRGINIA

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal[1]	Absorbed RfD for Dermal[2]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Semivolatile Organic Compounds										
Benzo(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	Chronic	3.0E-04	mg/kg/day	1	3.0E-04	mg/kg/day	Immune, Developmental, Reproductive	300	IRIS	6/12/2017
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Inorganics										
Aluminum, Total	Chronic	1.0E+00	mg/kg/day	1	1.0E+00	mg/kg/day	Nervous System	100	PPRTV	10/23/2006
Arsenic, Total	Chronic	3.0E-04	mg/kg/day	1	3.0E-04	mg/kg/day	Cardiovascular System, Dermal	3	IRIS	6/12/2017
Chromium, Total[3]	Chronic	3.0E-03	mg/kg/day	0.025	7.5E-05	mg/kg/day	None Reported	300	IRIS	6/12/2017
Iron, Total	Chronic	7.0E-01	mg/kg/day	1	7.0E-01	mg/kg/day	Gastrointestinal System	1.5	PPRTV	9/11/2006
Vanadium, Total[4]	Chronic	5.0E-03	mg/kg/day	0.026	1.3E-04	mg/kg/day	Dermal	300	IRIS	6/12/2017

Footnotes:

1 - USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

2 - Adjusted dermal RfD = Oral RfD x Oral Absorption Efficiency for Dermal.

3 - Values are for hexavalent chromium.

4 - Chronic value from IRIS adjusted as specified in the USEPA Regional Screening Level User Guide June 2017).

Definitions:

IRIS = Integrated Risk Information System

NA = Not Available.

PPRTV = Provisional Peer Reviewed Toxicity Value.

TABLE 2-6A

2013 RI NON-CANCER TOXICITY DATA -- INHALATION

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Extrapolated RfD		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC: Target Organ(s)	
		Value	Units	Value	Units			Source(s)	Date(s) (1) (MM/DD/YYYY)
Benzo[a]anthracene	---	NA	---	NA	---	---	---	---	---
Benzo[a]pyrene	---	NA	---	NA	---	---	---	---	---
Benzo[b]fluoranthene	---	NA	---	NA	---	---	---	---	---
Bis(2-ethylhexyl) phthalate	---	NA	---	NA	---	CNS	---	IRIS	4/2/2010
Chloroform	Chronic	9.80E-02	mg/m3	2.80E-02	mg/kg/day	---	---	---	---
Dibenz(a,h)anthracene	---	NA	---	NA	---	---	---	---	---
Indeno[1,2,3-cd]pyrene	---	NA	---	NA	---	CNS	100	ATSDR	RSL Table (12/09)
Tetrachloroethene	Chronic	2.70E-01	mg/m3	7.71E-02	mg/kg/day	CNS	300	PPRTV	RSL Table (12/09)
Aluminum, Total	Chronic	5.00E-03	mg/m3	1.43E-03	mg/kg/day	Developmental\Cardiovascular\CNS\Lung\Skin	30	Cal EPA	RSL Table (12/09)
Arsenic, Total	Chronic	1.50E-05	mg/m3	4.29E-06	mg/kg/day	---	---	---	---
Chromium, Total	---	NA	---	NA	---	---	---	---	---
Iron, Total	---	NA	---	NA	---	---	---	---	---
Vanadium, Total	---	NA	---	NA	---	---	---	---	---

(1) Represents date source was searched.

Definitions:

ATSDR = Agency for Toxic Substances and Disease Registry.
Cal EPA = California Environmental Protection Agency.
CNS=Central nervous system.
IRIS=Integrated Risk Information System.
NA=Not available.
PPRTV = EPA provisional peer-reviewed toxicity value.
RSL = Regional Screening Level.

TABLE 2-6B
2017 NON-CANCER TOXICITY DATA - INHALATION
SITE 9, WALLOPS FLIGHT FACILITY, VIRGINIA

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Extrapolated RfD[(1)]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units	Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Semivolatile Organic Compounds									
Benzo(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	Chronic	2.0E-06	mg/m^3	5.7E-07	(mg/kg/day)	Immune, Developmental, Reproductive	3000	IRIS	6/12/2017
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Inorganics									
Aluminum, Total	Chronic	5.0E-03	mg/m^3	1.4E-03	(mg/kg/day)	Nervous System	300	PPRTV	10/23/2006
Arsenic, Total	Chronic	1.5E-05	mg/m^3	4.3E-06	(mg/kg/day)	Cardiovascular System, Dermal	NA	Cal EPA	12/2008
Chromium, Total[(2)]	Chronic	1.0E-04	mg/m^3	2.9E-05	(mg/kg/day)	Respiratory System	300	IRIS	6/12/2017
Iron, Total	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium, Total	Chronic	1.0E-04	mg/m^3	2.9E-05	(mg/kg/day)	Respiratory	30	ATSDR	9/2012

Footnotes:

1 - Extrapolated RfD = RfC *$20m^3$/day / 70 kg

2 - Values are for hexavalent chromium.

Definitions:

ATSDR = Agency for Toxic Substances and Disease Registry.

Cal EPA = Technical Support Document for Noncancer RELs, Appendix D1.

IRIS = Integrated Risk Information System

NA = Not Applicable

PPRTV = Provisional Peer Reviewed Toxicity Value.

Table 2-7A

2013 RI SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs AGE-ADJUSTED ADULT REASONABLE MAXIMUM EXPOSURE

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Age-adjusted

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Surface/Subsurface Soils	Surface/Subsurface Soils at Site 9	Benzo[a]anthracene	4.2E-07	9.4E-12	1.7E-07	6E-07	---	---	---	---	---
			Benzo[a]pyrene	5.6E-06	1.2E-10	2.3E-06	8E-06	---	---	---	---	---
			Benzo[b]fluoranthene	3.4E-07	7.6E-12	1.4E-07	5E-07	---	---	---	---	---
			Dibenz(a,h)anthracene	8.0E-07	2.0E-11	3.3E-07	1E-06	---	---	---	---	---
			Indeno[1,2,3-cd]pyrene	2.6E-07	5.7E-12	1.1E-07	4E-07	---	---	---	---	---
			Aluminum, Total	---	---	---	---	---	---	---	---	---
			Arsenic, Total	5.9E-06	2.5E-09	5.6E-07	6E-06	---	---	---	---	---
			Chromium, Total	---	---	---	---	---	---	---	---	---
			Iron, Total	---	---	---	---	---	---	---	---	---
			Vanadium, Total	---	---	---	---	---	---	---	---	---
			Chemical Total	1.3E-05	2.7E-09	3.6E-06	2E-05		---	---	---	---
		Exposure Point Total					2E-05					---
	Exposure Medium Total						2E-05					---
Soil Total							2E-05					---
Groundwater	Groundwater	Tap water at Site 9	Bis(2-ethylhexyl) phthalate	1.3E-06	---	1.9E-06	3E-06	---	---	---	---	---
			Chloroform	2.3E-07	1.2E-10	2.0E-08	2E-07	---	---	---	---	---
			Tetrachloroethene	7.0E-05	1.0E-09	4.0E-05	1E-04	---	---	---	---	---
			Iron, Total	---	---	---	---	---	---	---	---	---
			Chemical Total	7.1E-05	1.1E-09	4.2E-05	1E-04		---	---	---	---
		Exposure Point Total					1E-04					---
	Exposure Medium Total						1E-04					---
Groundwater Total							1E-04					---
Sediment	Sediment	Sediment at Site 9	Chromium, Total	---	---	---	---	---	---	---	---	---
			Vanadium, Total	---	---	---	---	---	---	---	---	---
			Chemical Total	---	---	---	---		---	---	---	---
		Exposure Point Total					---					---
	Exposure Medium Total						---					---
Sediment Total							---					
Surface Water	Surface Water	Surface Water at Site 9	Tetrachloroethene	1.4E-07	---	7.9E-07	9E-07	---	---	---	---	---
			Chemical Total	1.4E-07	---	7.9E-07	9E-07		---	---	---	---
		Exposure Point Total					9E-07					---
	Exposure Medium Total						9E-07					---
Surface Water Total							9E-07					---
Receptor Total							1E-04					---

Total Risk Across All Media: 1E-04

Total Hazard Across All Media: ---

TABLE 2-7B

2017 SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS
AGE-ADJUSTED ADULT
REASONABLE MAXIMUM EXPOSURES

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Age-adjusted

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Surface/Subsurface Soil	Surface/Subsurface Soils at Site 9	Benzo(a)anthracene	2.4E-07	3.9E-09	8.0E-08	3E-07	--	--	--	--	--
			Benzo(a)pyrene	3.2E-06	1.6E-10	1.1E-06	4E-06	--	--	--	--	--
			Benzo(b)fluoranthene	1.9E-07	9.9E-12	6.5E-08	3E-07	--	--	--	--	--
			Dibenzo(a,h)anthracene	4.6E-07	2.3E-11	1.5E-07	6E-07	--	--	--	--	--
			Indeno(1,2,3-cd)pyrene	1.5E-07	7.5E-12	4.9E-08	2E-07	--	--	--	--	--
			Aluminum, Total	- -	- -	- -	- -	--	--	--	--	--
			Arsenic, Total	3.3E-06	2.2E-09	4.6E-07	4E-06	--	--	--	--	--
			Chromium, Total	2.9E-05	4.2E-07	3.0E-05	6E-05	--	--	--	--	--
			Iron, Total	- -	- -	- -	- -	--	--	--	--	--
			Vanadium, Total	- -	- -	- -	- -	--	--	--	--	--
			Chemical Total	3.7E-05	4E-07	3.2E-05	7E-05		--	--	--	--
		Exposure Point Total					7E-05					--
	Exposure Medium Total						7E-05					--
Medium Total							7E-05					--
Groundwater	Groundwater	Tap Water at Site 9	Bis(2-ethylhexyl)phthalate	1.1E-06	- -	- -	1E-06	--	--	--	--	--
			Chloroform	1.9E-07	2.6E-07	1.7E-08	5E-07	--	--	--	--	--
			Tetrachloroethene	2.3E-07	4.7E-08	1.3E-07	4E-07	--	--	--	--	--
			Iron, Total	- -	- -	- -	- -	--	--	--	--	--
			Chemical Total	1.5E-06	3.1E-07	1.5E-07	2E-06		--	--	--	--
		Exposure Point Total					2E-06					--
	Exposure Medium Total						2E-06					--
Medium Total							2E-06					--
Sediment	Sediment	Sediment at Site 9	Chromium, Total	3.5E-06	--	3.6E-06	7E-06	--	--	--	--	--
			Vanadium, Total	- -	--	- -	- -	--	--	--	--	--
			Chemical Total	3.5E-06	--	3.6E-06	7E-06		--	--	--	--
		Exposure Point Total					7E-06					--
	Exposure Medium Total						7E-06					--
Medium Total							7E-06					--
Surface Water	Surface Water	Surface Water at Site 9	Tetrachloroethene	4.9E-10	--	2.0E-09	3E-09	--	--	--	--	--
			Chemical Total	4.9E-10	--	2.0E-09	3E-09		--	--	--	--
		Exposure Point Total					3E-09					--
	Exposure Medium Total						3E-09					--
Medium Total							3E-09					--
Receptor Total							8E-05					--

Total Risk Across All Media 8E-05 --

TABLE 2-8A

2013 RI SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs FUTURE CHILD RESIDENT REASONABLE MAXIMUM EXPOSURE

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Surface/Subsurface Soils	Surface/Subsurface Soils at Site 9	Benzo[a]anthracene	---	---	---	---	---	---	---	---	---
			Benzo[a]pyrene	---	---	---	---	---	---	---	---	---
			Benzo[b]fluoranthene	---	---	---	---	---	---	---	---	---
			Dibenz(a,h)anthracene	---	---	---	---	---	---	---	---	---
			Indeno[1,2,3-cd]pyrene	---	---	---	---	---	---	---	---	---
			Aluminum, Total	---	---	---	---	CNS	1.2E-01	9.9E-04	3.3E-03	1E-01
			Arsenic, Total	---	---	---	---	Skin	1.1E-01	9.1E-05	9.0E-03	1E-01
			Chromium, Total	---	---	---	---	NOEL	7.7E-05	---	1.6E-04	2E-04
			Iron, Total	---	---	---	---	Gastrointestinal	1.0E-01	---	2.9E-03	1E-01
			Vanadium, Total	---	---	---	---	Hair	2.4E+00	---	2.6E+00	5E+00
			Chemical Total	---	---	---	---		2.8E+00	1.1E-03	2.6E+00	5E+00
		Exposure Point Total					---					5E+00
	Exposure Medium Total						---					5E+00
Soil Total							---					5E+00
Groundwater	Groundwater	Tap water at Site 9	Bis(2-ethylhexyl) phthalate	---	---	---	---	Liver	1.9E-02	---	2.9E-02	5E-02
			Chloroform	---	---	---	---	Liver	3.1E-03	1.3E-07	2.7E-04	3E-03
			Tetrachloroethene	---	---	---	---	Liver/Body weight	5.5E-02	1.5E-06	3.2E-02	9E-02
			Iron, Total	---	---	---	---	Gastrointestinal	2.3E-01	---	1.5E-03	2E-01
			Chemical Total	---	---	---	---		3.0E-01	1.6E-06	6.3E-02	4E-01
		Exposure Point Total					---					4E-01
	Exposure Medium Total						---					4E-01
Groundwater Total							---					4E-01
Sediment	Sediment	Sediment at Site 9	Chromium, Total	---	---	---	---	NOEL	1.5E-06	---	2.0E-05	2E-05
			Vanadium, Total	---	---	---	---	Hair	3.4E-02	---	2.2E-01	3E-01
			Chemical Total	---	---	---	---		3.4E-02	---	2.2E-01	3E-01
		Exposure Point Total					---					3E-01
	Exposure Medium Total						---					3E-01
Sediment Total												3E-01
Surface Water	Surface Water	Surface Water at Site 9	Tetrachloroethene	---	---	---	---	Liver/Body weight	1.7E-04	---	6.2E-04	8E-04
			Chemical Total	---	---	---	---		1.7E-04	---	6.2E-04	8E-04
		Exposure Point Total					---					8E-04
	Exposure Medium Total						---					8E-04
Surface Water Total							---					8E-04
Receptor Total							---					6E+00

TABLE 2-8A

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total

Total Risk Across All Media	---
Total Hazard Across All Media	6E+00
Total Hair HI Across All Media	**5E+00**
Total CNS HI Across All Media	1E-01
Total NOEL HI Across All Media	2E-04 (1)
Total Skin HI Across All Media	1E-01 (1)
Total Liver HI Across All Media	1E-01 (1)
Total Gastrointestinal HI Across All Media	3E-01 (1)
Total Body Weight HI Across All Media	9E-02 (1)

(1) Target organ specific HIs were recalculated due to transcription error in the RI (Weston 2013).

TABLE 2-8B

2017 SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS
FUTURE CHILD RESIDENT
REASONABLE MAXIMUM EXPOSURES

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virgina

Scenario Timeframe: Future
Receptor Population: Residents
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Surface/Subsurface Soil	Surface/Subsurface Soils at Site 9	Benzo(a)anthracene	- -	--	- -	- -	NA	--	--	--	--
			Benzo(a)pyrene	- -	--	- -	- -	Developmental, Immune, Reproductive	2.1E-02	1.3E-04	6.4E-03	3E-02
			Benzo(b)fluoranthene	- -	--	- -	- -	NA	--	--	--	--
			Dibenzo(a,h)anthracene	- -	--	- -	- -	NA	--	--	--	--
			Indeno(1,2,3-cd)pyrene	- -	--	- -	- -	NA	--	--	--	--
			Aluminum, Total	- -	--	- -	- -	Nervous System	1.2E-01	9.9E-04	2.8E-03	1E-01
			Arsenic, Total	- -	--	- -	- -	Dermal, CVS	6.4E-02	9.1E-05	7.6E-03	7E-02
			Chromium, Total	- -	--	- -	- -	None Specified	3.8E-02	4.9E-05	3.6E-02	7E-02
			Iron, Total	- -	--	- -	- -	GS	1.0E-01	--	2.4E-03	1E-01
			Vanadium, Total	- -	--	- -	- -	Dermal	3.4E-02	7.2E-05	3.1E-02	7E-02
			Chemical Total	- -	--	- -	- -		3.8E-01	1.3E-03	8.7E-02	5E-01
		Exposure Point Total					- -					5E-01
	Exposure Medium Total						- -					5E-01
Medium Total							- -					5E-01
Groundwater	Groundwater	Tap Water at Site 9	Bis(2-ethylhexyl)phthalate	- -	--	- -	- -	Hepatic	1.5E-02	--	--	2E-02
			Chloroform	- -	--	- -	- -	Hepatic	2.4E-03	3.1E-04	1.9E-04	3E-03
			Tetrachloroethene	- -	--	- -	- -	Nervous System, Ocular	7.2E-02	1.2E-02	3.8E-02	1E-01
			Iron, Total	- -	--	- -	- -	GS	1.8E-01	--	7.8E-04	2E-01
			Chemical Total	- -	--	- -	- -		2.7E-01	1.3E-02	3.9E-02	3E-01
		Exposure Point Total					- -					3E-01
	Exposure Medium Total						- -					3E-01
Medium Total							- -					3E-01
Sediment	Sediment	Sediment at Site 9	Chromium, Total	- -	--	- -	- -	None Specified	4.6E-03	--	4.3E-03	9E-03
			Vanadium, Total	- -	--	- -	- -	Dermal	2.9E-03	--	2.6E-03	6E-03
			Chemical Total	- -	--	- -	- -		7.5E-03	--	7.0E-03	1E-02
		Exposure Point Total					- -					1E-02
	Exposure Medium Total						- -					1E-02
Medium Total							- -					1E-02
Surface Water	Surface Water	Surface Water at Site 9	Tetrachloroethene	- -	--	- -	- -	Nervous System, Ocular	2.8E-04	--	7.3E-04	1E-03
			Chemical Total	- -	--	- -	- -		2.8E-04	--	7.3E-04	1E-03
		Exposure Point Total					- -					1E-03
	Exposure Medium Total						- -					1E-03
Medium Total							- -					1E-03
Receptor Total							- -				Receptor HI Total	8E-01

TABLE 2-8B

2017 SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS
FUTURE CHILD RESIDENT
REASONABLE MAXIMUM EXPOSURES

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virgina

Scenario Timeframe: Future
Receptor Population: Residents
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
							--					

Total Hazard Across All Media	8E-01
Total CVS HI Across All Media	7E-02
Total Developmental HI Across All Media	3E-02
Total GS HI Across All Media	3E-01
Total Hepatic HI Across All Media	2E-02
Total Immune HI Across All Media	3E-02
Total Nervous System HI Across All Media	2E-01
Total Ocular HI Across All Media	1E-01
Total Reproductive HI Across All Media	3E-02
Total Respiratory HI Across All Media	1E-04
Total None Specified HI Across All Media	8E-02

Table 2-9

Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern
Soils

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

CAS Number	Analyte	Number of Samples Analyzed	Number of Detected Samples	Minimum Detected Concentration	Maximum Detected Concentration [1]	Location of Maximum	Upper Depth of Maximum (feet)	Lower Depth of Maximum (feet)	Ecological Screening Benchmark										Final Screening Benchmark	No. Samples Exceeding Benchmark
									ECO-SSL[2]				ORNL[3,4,5]				BTAG			
									Avian	Invertebrate	Mammalian	Plant	Invertebrate	Microbe	Plant	Wildlife	Flora	Fauna		
	INORGANICS (MG/KG)																			
7429-90-5	Aluminum, Total	23	23	2620	13700	SITE9-SB13	0	0.5	NA	NA	NA	NA	NA	6.00E+02	5.00E+01	NA	1.00E+00	NA	1.00E+00	23
7440-38-2	Arsenic, Total	23	5	2.2	3.4	SITE9-SB13	0	0.5	4.30E+01	NA	4.60E+01	1.80E+01	6.00E+01	1.00E+02	1.00E+01	9.90E+00	3.28E+02	NA	9.90E+00	0
7440-39-3	Barium, Total	23	12	24.9	40.5	SITE9-TP24	0.5	2	NA	3.30E+02	2.00E+03	NA	NA	3.00E+03	5.00E+02	2.83E+02	4.40E+02	4.40E+02	2.83E+02	0
7440-70-2	Calcium, Total	23	1	1150	1150	SITE9-SB28	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	--	--
7440-47-3	Chromium, Total	23	23	3.5	12.2	SITE9-SB13	0	0.5	2.60E+01	NA	3.40E+01	NA	4.00E-01	1.00E+01	1.00E+00	1.61E+01	2.00E-02	7.50E-03	7.50E-03	23
7440-50-8	Copper, Total	23	10	2.8	4.5	SITE9-SB13	0	0.5	2.80E+01	8.00E+01	4.90E+01	7.00E+01	5.00E+01	1.00E+02	1.00E+02	3.70E+02	1.50E+01	NA	1.50E+01	0
7439-89-6	Iron, Total	23	23	1330	8120	SITE9-SB13	0	0.5	NA	NA	NA	NA	NA	2.00E+02	NA	NA	3.26E+03	1.20E+01	1.20E+01	23
7439-92-1	Lead, Total	23	19	2.6	10.8	SITE9-TP24	0.5	2	1.10E+01	1.70E+03	5.60E+01	1.20E+02	5.00E+02	9.00E+02	5.00E+01	4.05E+01	2.00E+00	1.00E-02	1.00E-02	19
7439-95-4	Magnesium, Total	23	9	569	876	SITE9-TP5	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	4.40E+03	4.40E+03	4.40E+03	0
7439-96-5	Manganese, Total	23	23	7.2	133	SITE9-TP24	0	0.5	4.30E+03	4.50E+02	4.00E+03	2.20E+02	NA	1.00E+02	5.00E+02	NA	3.30E+02	3.30E+02	1.00E+02	2
7439-97-6	Mercury, Total	23	3	0.037	0.043	SITE9-SB28	0	0.5	NA	NA	NA	NA	1.00E-01	3.00E+01	3.00E-01	5.10E-04	5.80E-02	5.80E-02	5.10E-04	3
7440-02-0	Nickel, Total	23	14	4.4	7.8	SITE9-SB13	0	0.5	2.10E+02	2.80E+02	1.30E+02	3.80E+01	2.00E+02	9.00E+01	3.00E+01	1.21E+02	2.00E+00	NA	2.00E+00	14
7440-62-2	Vanadium, Total	23	21	7.6	16.8	SITE9-SB13	0	0.5	7.80E+00	NA	2.80E+02	NA	NA	2.00E+01	2.00E+00	5.50E+01	5.00E-01	5.80E+01	5.00E-01	21
7440-66-6	Zinc, Total	23	23	3.2	19.7	SITE9-SB28	0.5	2	4.60E+01	1.20E+02	7.90E+01	1.60E+02	1.00E+02	1.00E+02	5.00E+01	8.50E+00	1.00E+01	NA	8.50E+00	16
	PESTICIDES (UG/KG)																			
72-54-8	4,4'-DDD	23	2	2.3	3.7	SITE9-SB10	0	0.5	9.30E+01	NA	2.10E+01	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	2.10E+01	0
72-55-9	4,4'-DDE	23	13	1.7	149	SITE9-SB10	0	0.5	9.30E+01	NA	2.10E+01	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	2.10E+01	2
50-29-3	4,4'-DDT	23	14	1.5	174	SITE9-SB10	0	0.5	9.30E+01	NA	2.10E+01	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	2.10E+01	2
72-43-5	Methoxychlor	23	1	2.4	2.4	SITE9-TP5	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	0
	PCBS (UG/KG)																			
	Not Detected																			
	SVOCS (UG/KG)																			
208-96-8	Acenaphthylene	23	3	21.8	268	SITE9-SB10	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	2
120-12-7	Anthracene	23	2	103	107	SITE9-TP7	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	2
56-55-3	Benzo[a]anthracene	23	3	36.4	368	SITE9-SB10	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	2
50-32-8	Benzo[a]pyrene	23	3	45.3	486	SITE9-SB10	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	2
205-99-2	Benzo[b]fluoranthene	23	3	29.2	297	SITE9-SB10	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	2
191-24-2	Benzo[g,h,i]perylene	23	3	38	250	SITE9-SB10	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	2
207-08-9	Benzo[k]fluoranthene	23	3	29.3	315	SITE9-SB10	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	2
218-01-9	Chrysene	23	3	41.8	441	SITE9-SB10	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	2
53-70-3	Dibenz(a,h)anthracene	23	2	57.1	70	SITE9-SB10	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	0
206-44-0	Fluoranthene	23	4	29.7	600	SITE9-SB10	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	2
193-39-5	Indeno[1,2,3-cd]pyrene	23	2	175	225	SITE9-SB10	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	2
85-01-8	Phenanthrene	23	3	17.2	177	SITE9-SB10	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	2
129-00-0	Pyrene	23	4	23.9	1020	SITE9-SB10	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	2
	VOCS (UG/KG)																			
67-64-1	Acetone	23	3	14.4	107	SITE9-SB13	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	--	--
100-41-4	Ethylbenzene	23	1	0.73	0.73	SITE9-TP24	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	1.00E+02	0
127-18-4	Tetrachloroethene	23	1	2	2	SITE9-TP24	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	3.00E+02	3.00E+02	3.00E+02	0
79-01-6	Trichloroethene	23	1	0.58	0.58	SITE9-TP24	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	3.00E+02	3.00E+02	3.00E+02	0
1330-20-7	Xylenes, Total	23	1	1.6	1.6	SITE9-TP24	0	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.00E+02	1.00E+02	0

Notes:

Maximum concentrations for shaded chemicals exceed screening benchmark.

Selected screening benchmark.

BTAG - Biological Technological Assistant Group

CAS = Chemical Abstracts Service

MG/KG = milligram per kilogram

NA = Not available

PCBs = Polychlorinated biphenyls

UG/KG = microgram per kilogram

SVOCs = Semivolatile organic compounds

VOCs = Volatile organic compounds

[1] Maximum detected concentration used for screening.

[2] EPA Ecological Soil Screening Levels (ECO-SSL) (http://www.epa.gov/ecotox/ecossl/).

[3] Oak Ridge National Laboratory (ORNL). Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. ORNL. ES/ER/TM-126/R2. November.

[4] ORNL. Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. ORNL. ES/ER/TM-85/R3. November.

[5] ORNL. Efroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones. 1997. Preliminary Remediation Goals for Ecological Endpoints. ORNL. ES/ER/TM-162/R2. August.

Table 2-10

Hazard Quotient Summary for Terrestrial Receptors
Soil

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

Contaminant	Red Fox LOAEL HQ	Red Fox NOAEL HQ	Red-tail Hawk LOAEL HQ	Red-tail Hawk NOAEL HQ	American Robin LOAEL HQ	American Robin NOAEL HQ	Short-tailed Shrew LOAEL HQ	Short-tailed Shrew NOAEL HQ
Organic Compounds								
4,4-DDD	1.3E-07	6.5E-07	7.8E-05	7.3E-04	2.0E-01	1.9E+00	2.2E-04	1.1E-03
4,4-DDE	4.7E-06	2.4E-05	2.8E-03	2.7E-02	7.3E+00	6.8E+01	8.0E-03	4.0E-02
4,4-DDT	3.6E-07	1.8E-06	2.2E-04	2.0E-03	5.6E-01	5.2E+00	6.2E-04	3.1E-03
Acetone	3.0E-07	1.5E-06	NA	NA	NA	NA	5.1E-04	2.6E-03
Acenaphthylene	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo[a]anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo[a]pyrene	1.3E-05	1.2E-04	NA	NA	NA	NA	2.2E-02	2.2E-01
Benzo[b]fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo[g,h,i]perylene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo[k]fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Indeno[1,2,3-cd]pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Inorganics								
Aluminum	9.7E-04	9.7E-03	9.6E-04	3.9E-04	2.4E+00	2.4E+00	1.7E+00	1.7E+01
Chromium	9.0E-05	3.6E-04	1.0E-03	5.0E-03	2.5E+00	1.3E+01	1.5E-01	6.1E-01
Iron	N	N	N	N	NA	N	N	N
Lead	3.9E-07	3.9E-06	1.2E-05	1.2E-04	2.9E-02	2.9E-01	6.6E-04	6.6E-03
Manganese	4.7E-07	1.0E-04	5.7E-07	5.7E-07	1.5E-03	1.5E-03	8.1E-04	2.6E-03
Mercury	2.7E-04	4.6E-04	5.8E-04	6.2E-03	1.5E+00	1.6E+01	9.4E-02	4.7E-01
Nickel	2.8E-07	5.6E-07	8.8E-07	1.2E-06	2.3E-03	3.1E-03	4.8E-04	9.5E-04
Vanadium	1.4E-05	1.4E-04	1.0E-05	1.0E-05	2.6E-03	2.6E-02	2.4E-02	2.4E-01
Zinc	9.4E-07	2.8E-06	1.4E-05	1.3E-04	3.7E-02	3.3E-01	2.4E-03	4.8E-03

Notes:

Shaded area indicates an exceedance of an HQ of 1.

NOAEL = No Observed Adverse Effect Level (Sample, 1996).

LOAEL = Lowest Observed Adverse Effect Level (Sample, 1996).

HQ = Hazard Quotient (Dose/LOAEL or NOAEL).

N/A = Not available

N = Nutrient

Table 2-11

Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern
Surface Water

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

CAS Number	Analyte	Number of Samples Analyzed[1]	Number of Detected Samples	Maximum Detected Concentration [1]	Location of Maximum	Ecological Screening Benchmark			Final Screening Benchmark	No. Samples Exceeding Benchmark
						BTAG Freshwater[2]	VDEQ[3] Freshwater Aquatic Life			
							Acute	Chronic		
	INORGANICS (MG/L)									
7429-90-5	Aluminum, Total	3	1	1	WFF9-SW2	0.087	NA	NA	0.087	1
7440-70-2	Calcium, Total	3	3	12.8	WFF9-SW2	116	NA	NA	116	0
7439-89-6	Iron, Total	3	3	6.27	WFF9-SW2	0.3	NA	NA	0.3	3
7439-92-1	Lead, Total	3	1	0.0033	WFF9-SW2	0.0025	1.20E-01	1.40E-02	0.0025	1
7439-95-4	Magnesium, Total	3	1	5.69	WFF9-SW3	82	NA	NA	82	0
7439-96-5	Manganese, Total	3	3	0.205	WFF9-SW1	0.12	NA	NA	0.12	2
7440-23-5	Sodium, Total	3	3	12.2	WFF9-SW2	680	NA	NA	680	0
	PESTICIDES (UG/L)									
	Non Detect									
	PCBS (UG/L)									
	Non Detect									
	SVOCS (UG/L)									
	Non Detect									
	VOCS (UG/L)									
540-59-0	1,2-Dichloroethene	3	1	0.51	WFF9-SW3	590	NA	NA	590	0
156-59-2	cis-1,2-Dichloroethene	3	1	0.51	WFF9-SW3	590	NA	NA	590	0
127-18-4	Tetrachloroethene	3	2	1.4	WFF9-SW3	111	NA	NA	111	0
79-01-6	Trichloroethene	3	1	0.54	WFF9-SW2	21	NA	NA	21	0

Notes:

Maximum concentrations for shaded chemicals exceed screening benchmarks.

CAS = Chemical Abstracts Service

MG/L = milligram per liter

NA = Not available

PCB = Polychlorinated biphenyl

UG/L = microgram per liter

SVOC = Semivolatile organic compound

VOC = Volatile organic compound

-- = not applicable

[1] Maximum detected concentration used for screening.

[2] United States Environmental Protection Agency (USEPA) Region III Biological Technical Assistance Group (BTAG) Freshwater Screening Benchmarks, July 2006.

[3] Virginia Department of Environmental Quality (VDEQ) Water Quality for Freshwater Acute and Chronic Aquatic Life Standards, October 2008.

Table 2-12

Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern
Sediment

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

CAS Number	Analyte	Number of Samples Analyzed[1]	Number of Detected Samples	Minimum Detected Concentration	Maximum Detected Concentration [1]	Location of Maximum	Upper Depth of Maximum (feet)	Lower Depth of Maximum (feet)	Ecological Screening Benchmark			Final Screening Benchmark	No. Samples Exceeding Benchmark
									BTAG Freshwater[2]	ISQG[3]	PEL[4]		
	INORGANICS (MG/KG)												
7429-90-5	Aluminum, Total	3	3	983	4600	WFF9-SE1	0	0.25	NA	NA	NA	NA	--
7440-47-3	Chromium, Total	3	3	2.5	7.5	WFF9-SE1	0	0.25	4.34E+01	3.73E+01	9.00E+01	3.73E+01	0
7439-89-6	Iron, Total	3	3	597	2430	WFF9-SE1	0	0.25	2.00E+04	NA	NA	2.00E+04	0
7439-92-1	Lead, Total	3	1	3.1	3.1	WFF9-SE1	0	0.25	3.58E+01	3.50E+01	9.13E+01	3.50E+01	0
7439-96-5	Manganese, Total	3	3	6.4	24.5	WFF9-SE1	0	0.25	4.60E+02	NA	NA	4.60E+02	0
7440-62-2	Vanadium, Total	3	1	7.9	7.9	WFF9-SE1	0	0.25	NA	NA	NA	NA	--
7440-66-6	Zinc, Total	3	3	3.3	10.5	WFF9-SE1	0	0.25	1.21E+02	1.23E+02	3.15E+02	1.21E+02	0
	PESTICIDES (UG/KG)												
72-54-8	4,4'-DDD	3	3	1.9	5.6	WFF9-SE1	0	0.25	4.88E+00	3.54E+00	8.51E+00	3.54E+00	1
72-55-9	4,4'-DDE	3	3	1.8	13.1	WFF9-SE1	0	0.25	3.16E+00	1.42E+00	6.75E+00	1.42E+00	3
50-29-3	4,4'-DDT	3	1	3.3	3.3	WFF9-SE1	0	0.25	4.16E+00	1.19E+00	4.77E+00	1.19E+00	1
	PCBS (UG/KG)												
	Not Detected												
	SVOCS (UG/KG)												
206-44-0	Fluoranthene	3	2	27.9	39.8	WFF9-SE2	0	0.25	4.23E+02	1.11E+02	2.36E+03	1.11E+02	0
85-01-8	Phenanthrene	3	1	25	25	WFF9-SE2	0	0.25	2.04E+02	4.19E+01	5.15E+02	4.19E+01	0
129-00-0	Pyrene	3	2	23.1	33.8	WFF9-SE2	0	0.25	1.95E+02	5.30E+01	8.75E+02	5.30E+01	0
	VOCS (UG/KG)												
67-64-1	Acetone	3	1	8.5	8.5	WFF9-SE1	0	0.25	NA	NA	NA	NA	--
75-15-0	Carbon disulfide	3	1	7.8	7.8	WFF9-SE1	0	0.25	8.51E-01	NA	NA	NA	--

Notes:

Maximum concentrations for shaded chemicals exceed screening benchmark.

CAS = Chemical Abstracts Service

MG/KG = milligram per kilogram

NA = Not available

PCB = Polychlorinated biphenyl

UG/KG = microgram per kilogram

SVOC = Semivolatile organic compound

VOC = Volatile organic compound

-- = not applicable

[1] Maximum detected concentration used for screening.

[2] USEPA Region III Biological Technical Assistance Group (BTAG) Freshwater Sediment Screening Benchmarks, August 2006.

[3] Interim sediment quality guideline (ISQG). Canadian Sediment Quality Guidelines for the Protection of Aquatic Life Summary Tables. In: Canadian Environmental Quality Guidelines, 2002, Canadian Council of Ministers of Environment, Winnipeg.

[4] Probably Effect Level (PEL). Canadian Sediment Quality Guidelines for the Protection of Aquatic Life Summary Tables. In: Canadian Environmental Quality Guidelines, 2002, Canadian Council of Ministers of Environment, Winnipeg.

Table 2-13

Hazard Quotient Summary
Sediment

Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

Contaminant	Mink LOAEL HQ	Mink NOAEL HQ	Raccoon LOAEL HQ	Raccoon NOAEL HQ	Great-blue Heron LOAEL HQ	Great-blue Heron NOAEL HQ
Organic Compounds						
4,4-DDD	7.9E-08	3.9E-07	4.6E-08	2.3E-07	1.5E-03	1.4E-02
4,4-DDE	3.3E-07	1.6E-06	1.9E-07	9.6E-07	6.1E-03	5.7E-02
4,4-DDT	4.7E-07	2.3E-06	2.7E-07	1.4E-06	8.6E-03	8.0E-02
Acetone	2.9E-07	1.5E-06	NA	NA	NA	NA
Carbon disulfide	NA	NA	NA	NA	NA	NA
Inorganics						
Aluminum	7.4E-04	7.4E-03	5.6E-04	5.6E-03	2.2E-02	9.1E-03
Vanadium	6.2E-06	6.2E-05	4.7E-06	4.7E-05	1.4E-05	1.4E-04

Notes:

NOAEL = No Observed Adverse Effect Level (Sample, 1996).

LOAEL = Lowest Observed Adverse Effect Level (Sample, 1996).

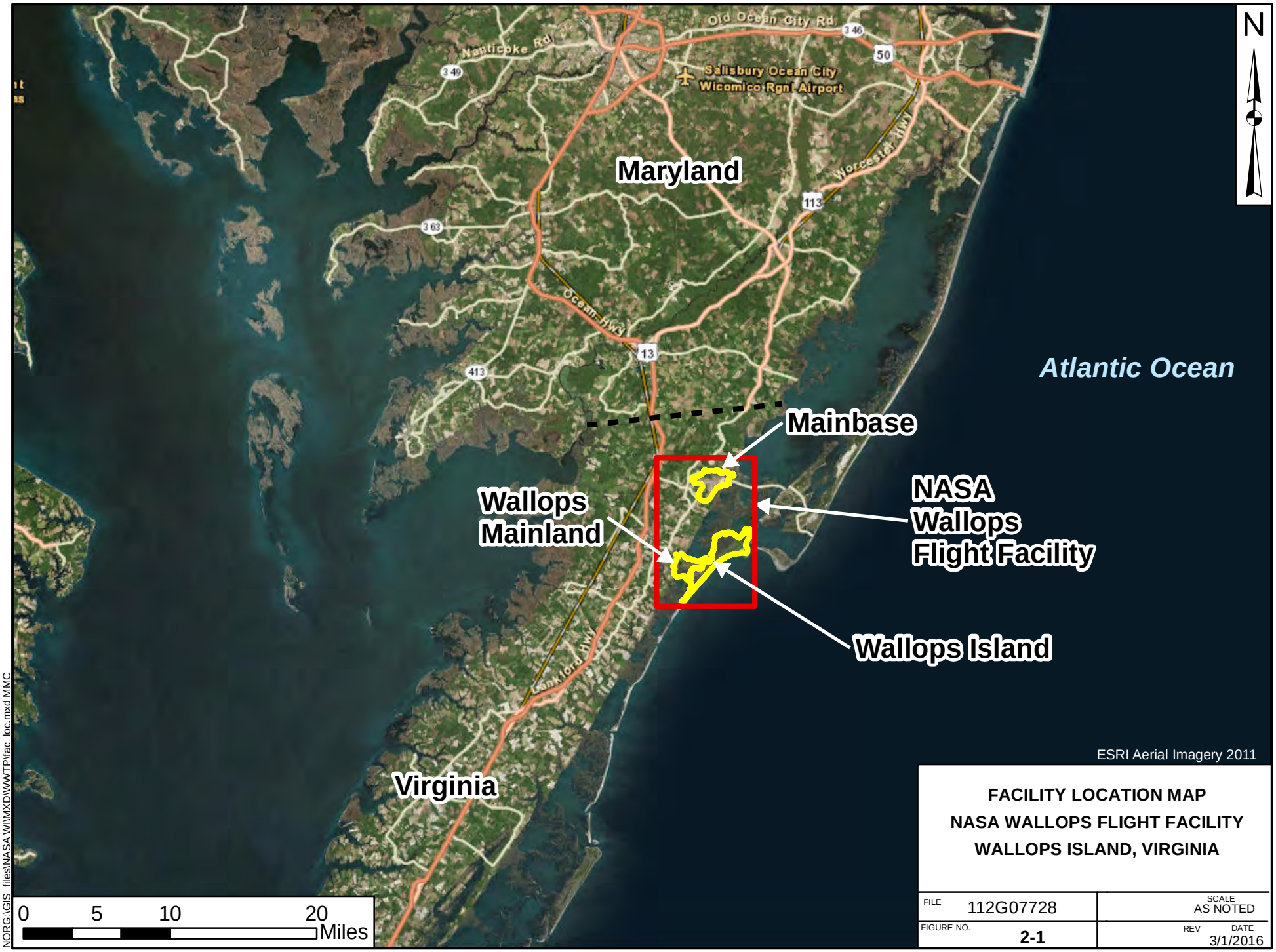
HQ = Hazard Quotient (Dose/LOAEL or NOAEL).

NA = Not Available

Table 2-14
Assessment and Measurement Endpoints
Site 9 - Drum Disposal Area NASA Wallops
Flight Facility Wallops Island, Virginia

Target Receptors or Communities	Assessment Endpoints	Measurement Endpoints
Vegetation in the terrestrial areas of the Site.	Survival, germination, and growth of plants in the terrestrial areas of the Site.	Comparison of chemical concentrations in soils with phytotoxic effects thresholds found in literature for plants.
Soil fauna in the terrestrial areas of the Site.	Survival, reproduction, and growth of soil fauna in the terrestrial areas of the Site.	Comparison of chemical concentrations in soils with toxic effects thresholds found in literature for soil invertebrates and microbial processes. Comparison of chemical concentrations in earthworm tissue with toxic effects residue concentrations.
Insectivorous birds foraging in the terrestrial areas of the Site.	Survival, reproduction, and growth of birds foraging in the terrestrial areas of the Site.	Modeling of soil invertebrate chemical accumulation, and avian (American robin) dietary exposure modeling. Comparison of dietary exposure doses with reference toxicity values for birds.
Insectivorous and carnivorous mammals foraging the terrestrial areas of the Site.	Survival, reproduction, and growth of mammals foraging in the terrestrial areas of the Site.	Analysis of soil invertebrate and small mammal tissue chemical accumulation, and mammalian (short-tailed shrew and red fox) dietary exposure modeling. Comparison of dietary exposure doses with reference toxicity values for mammals.
Benthic invertebrate community in the unnamed tributary of Little Mosquito Creek.	Survival, reproduction, growth, and indigenous community composition of benthic organisms in the unnamed tributary of Little Mosquito Creek.	Comparisons of chemical concentrations in sediment and surface water with criteria and guidance values for freshwater and estuarine sediments and surface waters as appropriate.
Fish community in Little Mosquito Creek and potentially its unnamed tributary.	Survival, reproduction, growth, and indigenous community composition of fish species in Little Mosquito Creek and potentially its unnamed tributary.	Comparisons of chemical concentrations in surface water to freshwater and estuarine criteria and guidance values as appropriate. Comparison of chemical concentrations in fish tissue with toxic effects residue concentrations.
Piscivorous birds foraging in the unnamed tributary.	Survival, reproduction, and growth of piscivorous birds foraging in the unnamed tributary.	Modeling fish tissue concentrations using site-specific data. Avian (great blue heron) dietary exposure modeling. Comparison of dietary exposure doses with reference toxicity values for birds.
Piscivorous birds foraging in Little Mosquito Creek.	Survival, reproduction, and growth of piscivorous birds foraging in Little Mosquito Creek.	Analysis of site-specific benthic invertebrate, crustacean, and fish tissue concentrations and avian (kingfisher and great blue heron) dietary exposure modeling. Comparison of dietary exposure doses with reference toxicity values for birds.
Piscivorous mammal foraging in the drainage ditch or Little Mosquito Creek.	Survival, reproduction, and growth of piscivorous mammal foraging in the drainage ditch or Little Mosquito Creek.	Analysis of site-specific benthic invertebrate, crustacean, and fish tissue concentrations and mammalian (mink) dietary exposure modeling. Comparison of dietary exposure doses with reference toxicity values for mammals.

FIGURES



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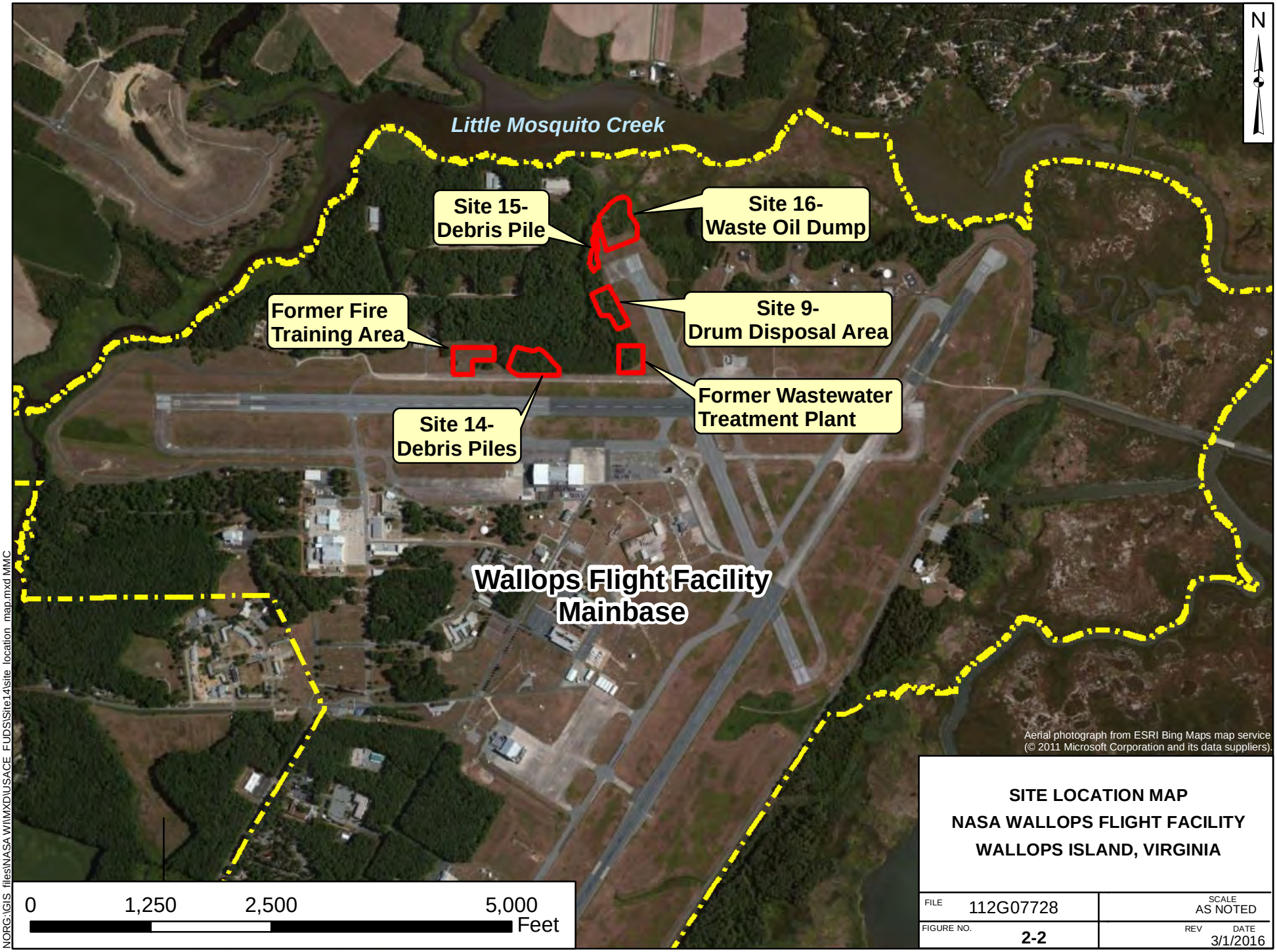
FACILITY LOCATION MAP
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

FILE	112G07728	SCALE	AS NOTED
FIGURE NO.	**2-1**	REV DATE	3/1/2016



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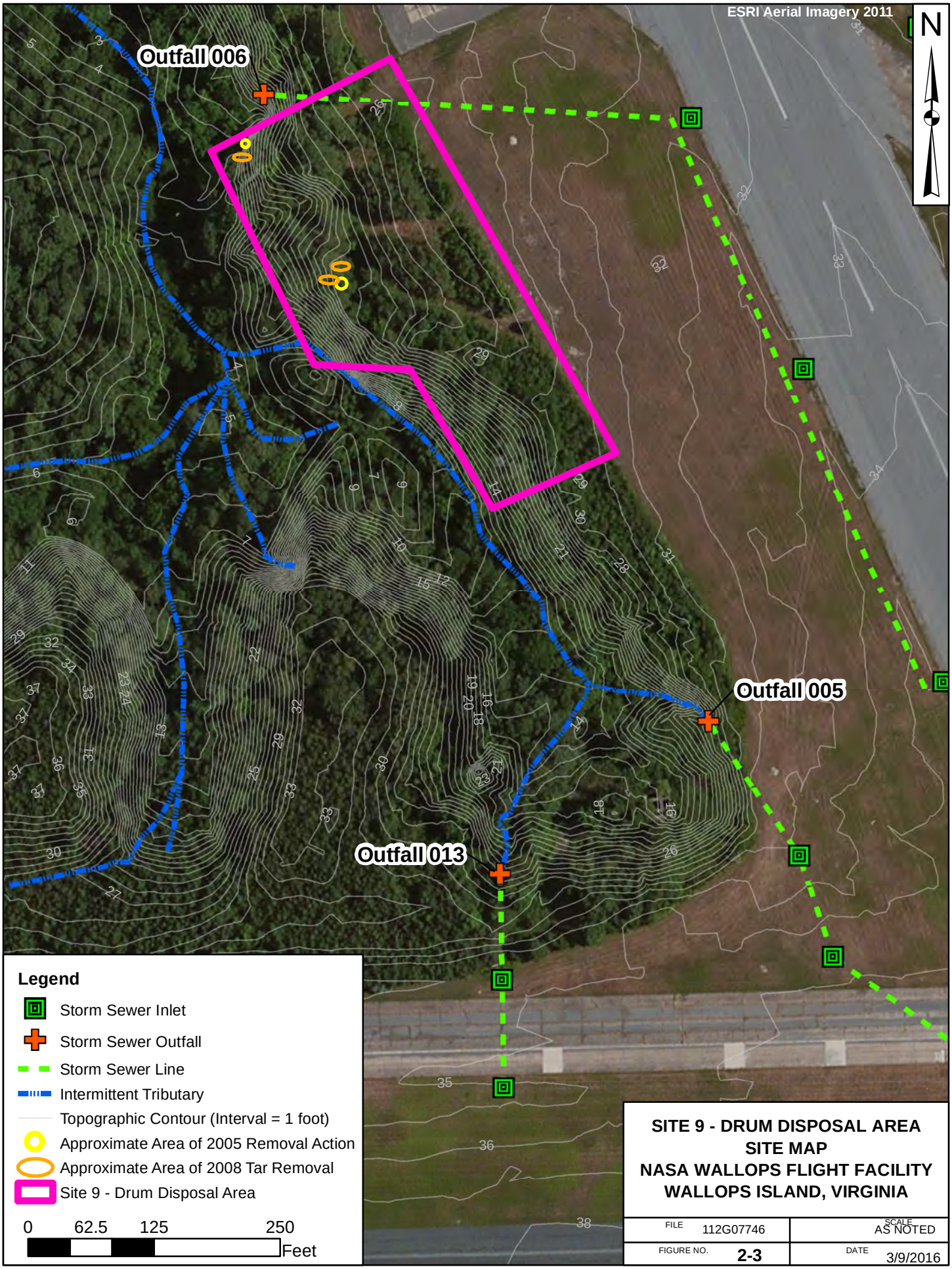
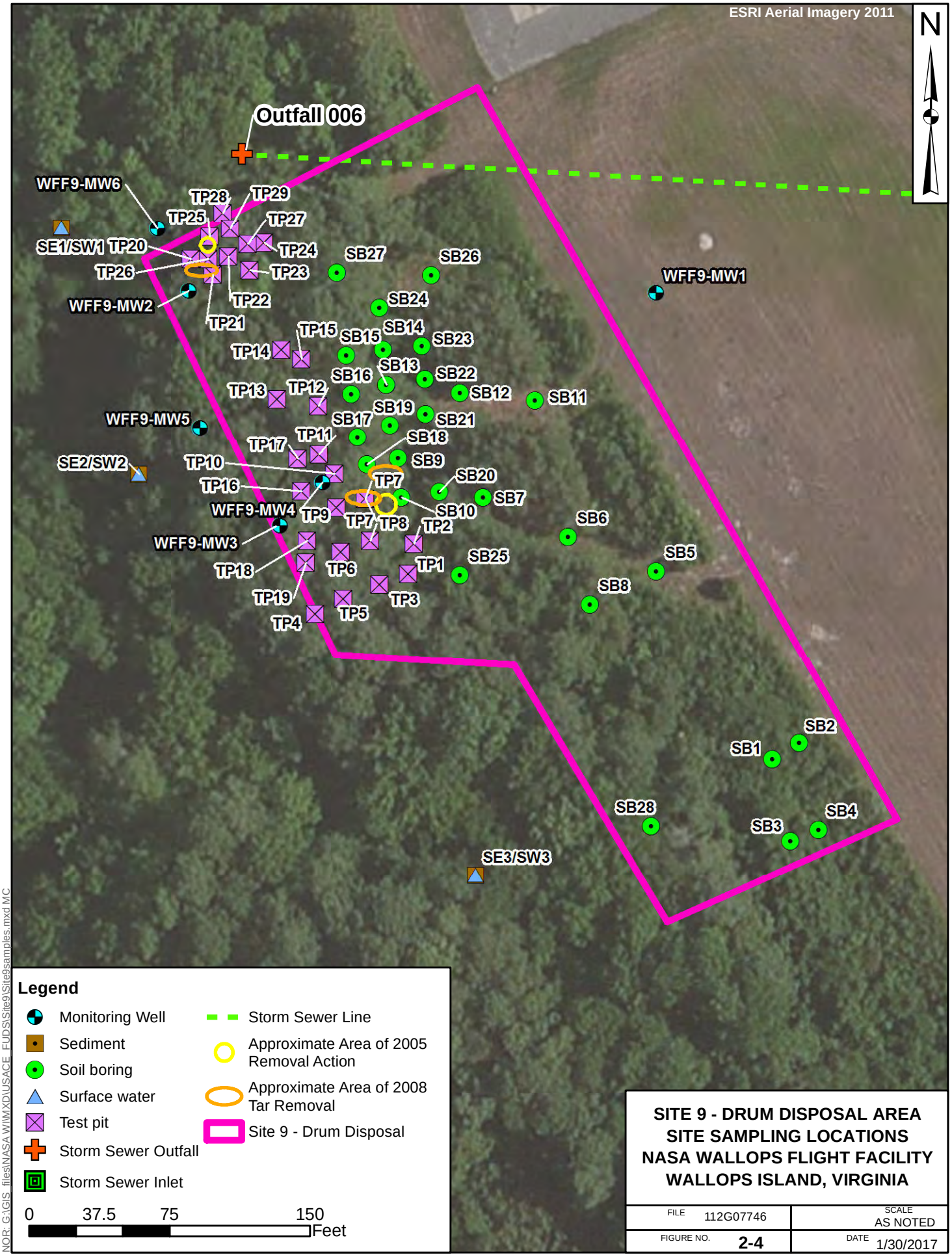
SITE LOCATION MAP
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

FILE	112G07728	SCALE	AS NOTED
FIGURE NO.	**2-2**	REV DATE	3/1/2016


ESRI Aerial Imagery 2011
N
Outfall 006
Outfall 005
Outfall 013
Legend
Storm Sewer Inlet
Storm Sewer Outfall
Storm Sewer Line
Intermittent Tributary
Topographic Contour (Interval = 1 foot)
Approximate Area of 2005 Removal Action
Approximate Area of 2008 Tar Removal
Site 9 - Drum Disposal Area
0 62.5 125 250
Feet
SITE 9 - DRUM DISPOSAL AREA
SITE MAP
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA
FILE 112G07746
SCALE AS NOTED
FIGURE NO. 2-3
DATE 3/9/2016



SITE 9 - DRUM DISPOSAL AREA
SITE SAMPLING LOCATIONS
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

FILE	112G07746	SCALE	AS NOTED
FIGURE NO.	**2-4**	DATE	1/30/2017

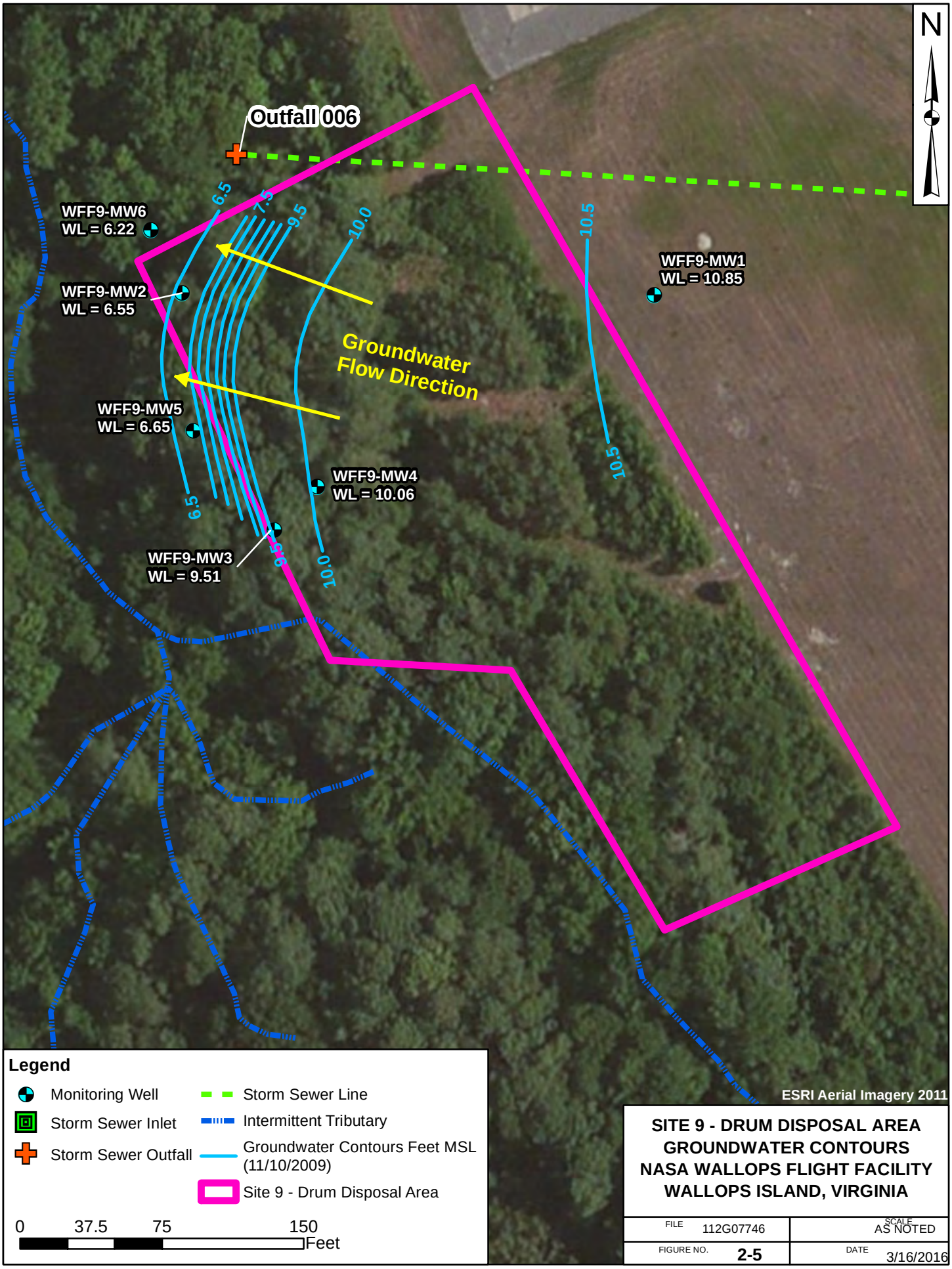
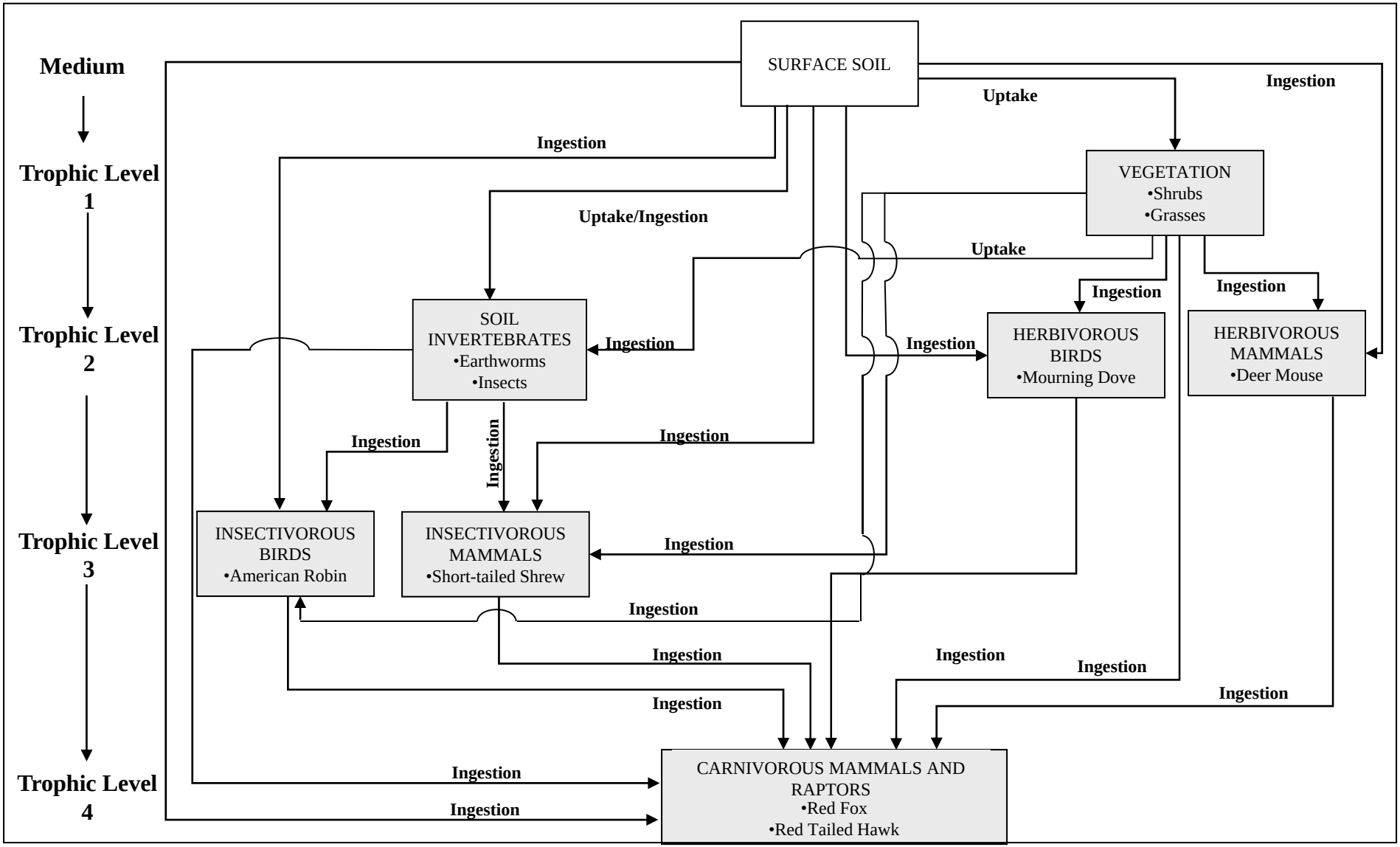

N
Outfall 006
WFF9-MW6
WL = 6.22
WFF9-MW2
WL = 6.55
WFF9-MW5
WL = 6.65
WFF9-MW3
WL = 9.51
WFF9-MW4
WL = 10.06
WFF9-MW1
WL = 10.85
Groundwater
Flow Direction
6.5
7.5
9.5
10.0
10.5
9.5
9.5
10.0
10.5
Legend
Monitoring Well
Storm Sewer Inlet
Storm Sewer Outfall
Storm Sewer Line
Intermittent Tributary
Groundwater Contours Feet MSL (11/10/2009)
Site 9 - Drum Disposal Area
0
37.5
75
150
Feet
ESRI Aerial Imagery 2011
SITE 9 - DRUM DISPOSAL AREA
GROUNDWATER CONTOURS
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA
FILE 112G07746
SCALE AS NOTED
FIGURE NO. 2-5
DATE 3/16/2016

Figure 2-6
Human Health Conceptual Site Model
Site 9 - Drum Disposal Area NASA Wallops
Flight Facility Wallops Island, Virginia
Page 1 of 2

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	Surface Soil	Surface Soil (0-2 ft)	Surface Soil	Trespasser	Adolescent Child	Ingestion	On-Site	Quantitative	Trespasser incidentally ingests soil
						Dermal Contact	On-Site	Quantitative	Trespasser contacts soils
		Air	Airborne dust and VOCs from soil			Inhalation	On-Site	Quantitative	Trespasser inhales outdoor dust and VOCs from soil
	Sludge	Sludge	Sludge			Ingestion	On-Site	Quantitative	Trespasser incidentally ingests sludge
						Dermal Contact	On-Site	Quantitative	Trespaser contacts sludge
	Sediment	Sediment	Intermittent Stream Sediment			Ingestion	Off-site	Quantitative	Trespasser ingests sediment while wading
						Dermal Contact	Off-site	Quantitative	Trespasser contacts sediment while wading
	Surface water	Surface water	Intermittent Stream Surface Water			Ingestion	Off-site	Quantitative	Child ingests surface water while wading
						Dermal Contact	Off-site	Quantitative	Child contacts surface water while wading
	Waste water	Waste water	Waste water in settling tank			Dermal Contact	On-Site	Quantitative	Child contacts waste water from settling tank while trespassing
Future	Surface Soil	Surface Soil (0-2 ft)	Surface Soil	Industrial Worker	Adult	Ingestion	On-Site	Quantitative	Worker incidentally ingests soils
						Dermal Contact	On-Site	Quantitative	Worker contacts soils
		Air	Airborne dust and VOCs from soil			Inhalation	On-Site	Quantitative	Worker inhales dust and VOCs from soil
	Subsurface Soil	Subsurface Soil (2-10 ft)	Subsurface Soil			Ingestion	On-Site	Quantitative	Worker incidentally ingests soils
						Dermal Contact	On-Site	Quantitative	Worker contacts soils
		Air	Airborne dust and VOCs from soil			Inhalation	On-Site	Quantitative	Worker inhales dust and VOCs from soil
	Sludge	Sludge	Sludge			Ingestion	On-Site	Quantitative	Worker incidentally ingests sludge
						Dermal Contact	On-Site	Quantitative	Worker contacts sludge
	Waste water	Waste water	Waste water in settling tank			Dermal Contact	On-Site	Quantitative	Worker contacts waste water from settling tank
	Surface Soil	Surface Soil (0-2 ft)	Surface Soil	Construction Worker	Adult	Ingestion	On-Site	Quantitative	Worker incidentally ingests soils
						Dermal Contact	On-Site	Quantitative	Worker contacts soils
		Air	Airborne dust and VOCs from soil			Inhalation	On-Site	Quantitative	Worker inhales outdoor dust and VOCs from soil
	Subsurface Soil	Subsurface Soil (2-10 ft)	Subsurface Soil			Ingestion	On-Site	Quantitative	Worker incidentally ingests soils
						Dermal Contact	On-Site	Quantitative	Worker contacts soils
		Air	Airborne dust and VOCs from soil			Inhalation	On-Site	Quantitative	Worker inhales outdoor dust and VOCs from soil

Figure 2-6
Selection of Exposure Pathways
Site 9 - Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future (continued)	Sludge	Sludge	Sludge	Construction Worker	Adult	Ingestion	On-Site	Quantitative	Worker incidentally ingests sludge
						Dermal Contact	On-Site	Quantitative	Worker contacts sludge
	Groundwater	Groundwater	Groundwater in construction trenches			Dermal Contact	On-Site	Quantitative	Worker contacts groundwater that infiltrates construction trenches
	Waste water	Waste water	Waste water in settling tank			Dermal Contact	On-Site	Quantitative	Worker contacts waste water from settling tank during construction activities
	Surface Soil	Surface Soil (0-2 ft)	Surface Soil	Resident	Child/Adult	Ingestion	On-Site	Quantitative	Resident incidentally ingests soils
						Dermal Contact	On-Site	Quantitative	Resident contacts soils
		Air	Airborne dust and VOCs from soil		Child/Adult	Inhalation	On-Site	Quantitative	Resident inhales outdoor dust and VOCs from soil
	Subsurface Soil	Subsurface Soil (2-10 ft)	Subsurface Soil		Child/Adult	Ingestion	On-Site	Quantitative	Resident incidentally ingests soils
						Dermal Contact	On-Site	Quantitative	Resident contacts soils
		Air	Airborne dust and VOCs from soil		Child/Adult	Inhalation	On-Site	Quantitative	Resident inhales outdoor dust and VOCs from soil
	Sediment	Sediment	Intermittent Stream Sediment		Child/Adult	Ingestion	Off-site	Quantitative	Resident ingests sediment while wading
						Dermal Contact	Off-site	Quantitative	Resident contacts sediment while wading
	Surface water	Surface water	Intermittent Stream Surface Water		Child/Adult	Ingestion	Off-site	Quantitative	Resident ingests surface water while wading
						Dermal Contact	Off-site	Quantitative	Resident contacts surface water while wading
	Groundwater	Groundwater	Tap water		Child/Adult	Ingestion	On-Site	Quantitative	Resident drinks water
						Dermal Contact	On-Site	Quantitative	Resident dermally absorbs contaminants while bathing/showering
					Child/Adult	Inhalation	On-Site	Quantitative	Resident inhales VOCs while bathing/showering
		Air	Vapor Intrusion		Child/Adult	Inhalation	On-Site	Quantitative	Resident inhales VOCs from vapor intrusion into basement of building.

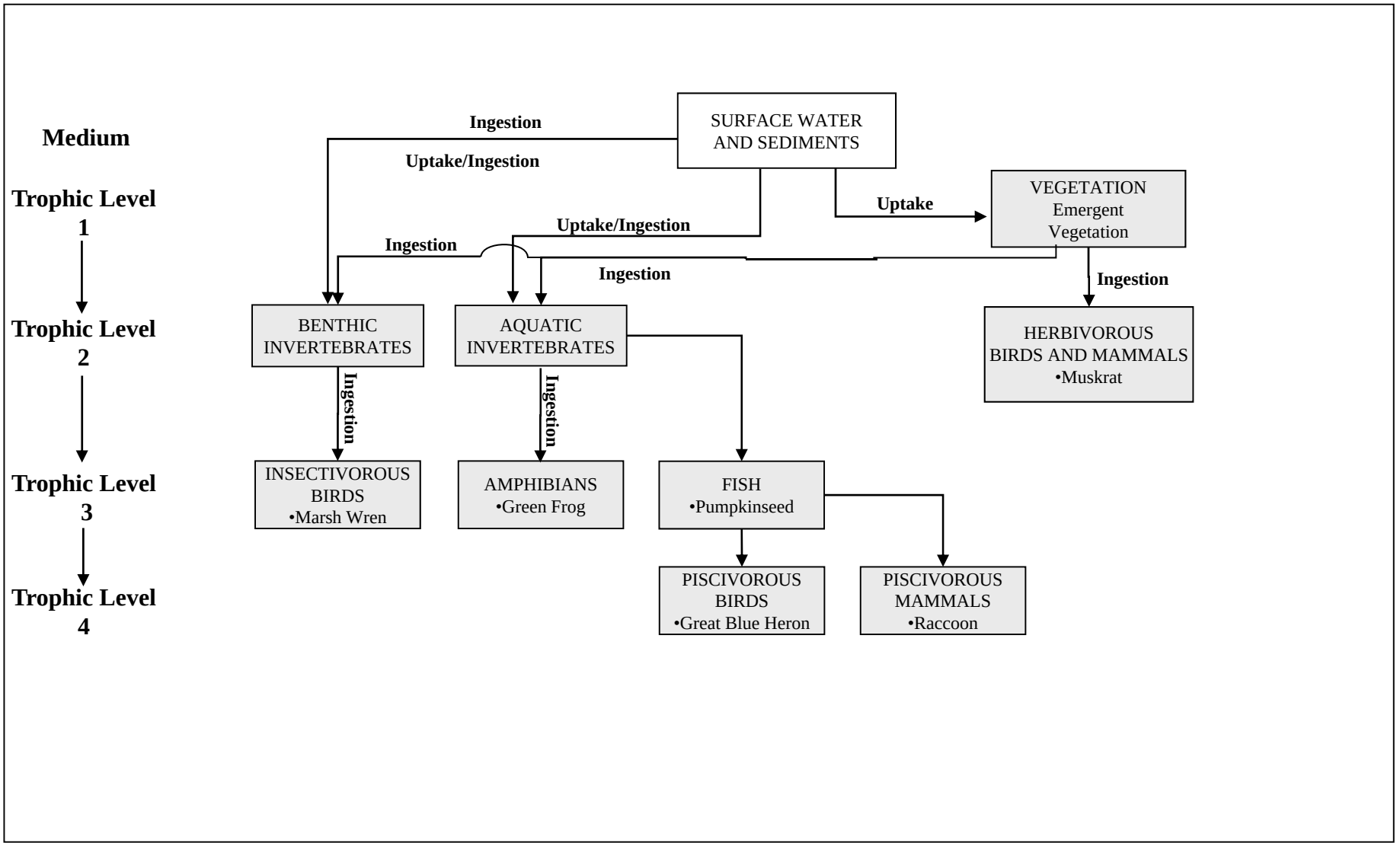


LEGEND

- • Representative species
- → Pathway evaluated for at least one species in feeding guild
- ▭ Feeding guild to be evaluated

Figure 2-7

Site Conceptual Model for the Terrestrial Ecosystem
Site 9 –Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia



LEGEND

- • Representative species
- → Pathway evaluated for at least one species in feeding guild
- ▭ Feeding guild to be evaluated

Figure 2-8

Site Conceptual Model for the Aquatic Ecosystem
Site 9 – Drum Disposal Area
NASA Wallops Flight Facility
Wallops Island, Virginia