REVISED FINAL

FEASIBILITY STUDY REPORT FOR FOX ROAD, SNAKE ROAD, AND TAYLOR ROAD BURNING GROUNDS

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January 2023

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LIST OF REVISIONS

Date	Section	Revision Description	Responsible Person
January 2023	All	• Add Executive Summary. • Add information regarding Phase II Remedial Investigation for groundwater. • Add information regarding removal of asbestos; adds Fox Road Burning Ground as a site detailed in this Feasibility Study. • Update Remedial Cleanup Goals. • Update volumes and pricing in 2022 dollars. • Revision of initially retained technologies based on presence and planned removal of asbestos containing material. • Add information on Supplemental Risk Evaluation (Appendix A). • Add Green and Sustainable Remediation Evaluation (Appendix B).	Leidos

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Appendix B Green and Sustainable Remediation (GSR) Evaluation
Appendix C Detailed Cost Estimates (*revised January 2023*)

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ACRONYMS

ACM	Asbestos-Containing Material
ARAR	Applicable or Relevant and Appropriate Requirement
ATF	Neil A. Armstrong Test Facility
bgs	Below Ground Surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMCOPC	Contaminant Migration Chemical of Potential Concern
COC	Chemical of Concern
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CUG	Cleanup Goal
CY	Cubic Yard(s)
DNT	Dinitrotoluene
EnviroSafe	EnviroSafe Services of Ohio, Inc.
ERA	Ecological Risk Assessment
ESL	Ecological Screening Level
ESV	Ecological Screening Value
EU	Exposure Unit
F&T	Fate and Transport
FRBG	Fox Road Burning Ground
FS	Feasibility Study
GHG	Greenhouse Gases
GRA	General Response Action
GRC	John H. Glenn Research Center
GSR	Green and Sustainable Remediation
HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
LDR	Land Disposal Restriction
LUC	Land Use Control
mg/kg	Milligram per Kilogram
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	Non Detect
NFA	No Further Action
NOx	Oxides of Nitrogen
O&M	Operation and Maintenance
OAC	Ohio Administrative Code
Ohio EPA	Ohio Environmental Protection Agency
ORC	Ohio Revised Code
PCB	Polychlorinated Biphenyl

ACRONYMS (Continued)

PM10	Particulates less than 10 Micrometers
PP	Proposed Plan
ppm	Parts per Million
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
RSL	Regional Screening Level
SRBG	Snake Road Burning Ground
SOx	Oxides of Sulfur
T&E	Threatened and Endangered
TBC	To-Be-Considered
TCLP	Toxicity Characteristic Leaching Procedure
TRBG	Taylor Road Burning Ground
TSCA	Toxic Substances Control Act
USEPA	U.S. Environmental Protection Agency

EXECUTIVE SUMMARY

This Revised Final Feasibility Study (FS) summarizes the evaluation for three of the seven sites identified in the *Multi-Site Remedial Investigation Sampling and Analysis Plan* (Leidos 2016a). The sites discussed in this FS Report are Fox Road Burning Ground (FRBG), Snake Road Burning Ground (SRBG), and Taylor Road Burning Ground (TRBG). The RI Reports for FRBG, SRBG, and TRBG concluded that the nature and extent of contamination at each site was adequately defined in accordance with CERCLA requirements. Soil requiring remediation at FRBG, SRBG, and TRBG was identified.

The objectives of this FS were to summarize findings and recommendations from the Revised Final Phase I RI Report, the Final Phase II RI Reports, and the supplemental risk evaluations; identify areas with chemicals of concern (COCs) requiring remedial action and develop remediation goals; present potential chemical-, action-, and location-specific ARARs; identify, evaluate, and select the appropriate technologies for incorporation as components of the remedial alternatives; perform a detailed and comparative analysis of alternatives using the threshold and balancing evaluation criteria established by USEPA; and provide a recommended alternative for each site.

As part of this Revised Final FS a human health and ecological supplement risk evaluation was completed to determine if methods and/or soil screening values have changed since the soils RIs and FS were conducted in 2018. After examining the newly calculated risks and the existing cumulative risks, no new human health soil COCs or ecological COPECs were identified at any of the burning grounds.

CUGs establish acceptable exposure levels to be protective of human health and the environment while considering potential land uses and provide the basis for screening, evaluating, and selecting a remedial alternative. The volumes of soil requiring remedial response action within FRBG, SRBG, and TRBG were calculated based on the lateral and vertical extent of soil containing one or more COCs above the CUGs or detectable asbestos.

The extent of soil contamination posing a risk to hypothetical residential receptors was limited to surface soil (0 to 2 ft bgs) at FRBG and SRBG, and limited to surface soil (0 to 2 ft bgs) and shallow subsurface soil (2 to 6 ft bgs) at TRBG. The extent of soil contamination posing a risk to ecological receptors was limited to surface soil (0 to 2 ft bgs) at SRBG. Consequently, remedial alternatives were developed and evaluated to determine the most feasible alternative for FRBG, SRBG, and TRBG.

General response actions were evaluated followed by an initial and detailed screening of technologies for each site. The initial screening focused on technology types capable of remediating COCs present at the three sites and evaluates the implementability of the technology. The remedial action technologies retained from the initial screening process were evaluated against criteria of effectiveness, implementability, and cost (three of the NCP balancing criteria). The remedial options retained from the detailed screening process used to develop the remedial alternatives

Remedial alternatives were developed for individual and comparative evaluation using the threshold and balancing criteria established by USEPA to address CERCLA criteria and statutory considerations. A detailed analysis of the alternatives was conducted against the "threshold" and "balancing" criteria, and alternative GSR criteria, followed by a comparative analysis, to determine the advantages or disadvantages of each alternative with respect to each other. Two remedial alternatives were developed and evaluated to address soil contamination at FRBG, SRBG, and TRBG:

- Alternative 1: No Action; and
- Alternative 2: Excavation and Offsite Disposal – Attain Residential Land Use.

While Alternative 1 is not protective or compliant with all the NCP threshold criteria, Alternative 2 is fully compliant with the NCP criteria and is the recommended alternative for FRBG, SRBG, and TRBG. Under this recommended alternative, all contaminated soil with COC or detectable asbestos concentrations exceeding remedial CUGs will be excavated and disposed offsite. Implementation of Alternative 2 would result in excavation and offsite disposal of approximately 56 CY of contaminated soil from FRBG, approximately 2,056 CY of contaminated soil from SRBG, and approximately 1,543 CY of contaminated soil from TRBG. The excavation will be backfilled with clean native fill material from a NASA-approved source and seeded with grass cover to restore the excavated area to the surrounding site conditions. There will be no O&M activities or 5-year CERCLA reviews necessary under this alternative because the remedial action will attain CUGs protective of residential land use conditions. The total present value cost for recommended Alternative 2 at FRBG, SRBG, and TRBG is estimated to be $3,233,451.

1.0 INTRODUCTION

Leidos has prepared this Revised Final Feasibility Study (FS) Report on behalf of the National Aeronautics and Space Administration (NASA) John H. Glenn Research Center (GRC) at Neil A. Armstrong Test Facility (GRC-ATF) (formerly named Plum Brook Station) in Sandusky, Ohio (Figure 1-1). This report summarizes the FS evaluation for three of the seven sites identified in the *Multi-Site Remedial Investigation Sampling and Analysis Plan* (Leidos 2016a). The sites discussed in this FS Report are Fox Road Burning Ground (FRBG), Snake Road Burning Ground (SRBG), and Taylor Road Burning Ground (TRBG). Remedial Investigation (RI) activities, the RI data, analysis, and conclusions were previously reported for soil, sediment, and surface water in the combined Revised Final Phase I RI Report for all three sites (Leidos 2022a, originally submitted separately in 2018). Phase II RI activities were completed in 2021 for groundwater and are reported in the Final Phase II RI Reports for each site (Leidos 2022b, 2022c, and 2022d).

The RI/FS was conducted in accordance with U.S. Environmental Protection Agency (USEPA) and Ohio Environmental Protection Agency (Ohio EPA) guidance. Investigative activities were conducted in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

1.1 PURPOSE OF REPORT

In accordance with the NCP and 40 Code of Federal Regulations (CFR) 300.430(e)(1), the primary objective of the FS is to ensure that appropriate remedial alternatives are developed and evaluated so that relevant information concerning the remedial action alternatives can be presented to a decision-maker and an appropriate remedy selected. Therefore, the purpose of this FS is to evaluate any contaminated soil media at FRBG, SRBG, and TRBG that pose a potential risk to human health and the environment and identify remedial action objectives (RAOs) and appropriate cleanup goals (CUGs), screen remedial technologies, develop remedial alternatives to meet the RAOs and attain CUGs, and perform a detailed evaluation of remedial alternatives to identify a preferred remedy. This FS was revised to incorporate the recommendations of the supplemental risk evaluation (Appendix A) and evaluating the additional removal of detectable asbestos in surface soil consistent with USEPA guidance (USEPA 2004).

Each site also contains debris that NASA can consider removing as part of the remedial action. The Revised RI Reports provide some detail about this debris; however, it is worth noting that this remaining debris (i.e., metal scrap, cinder blocks) does not pose an additional chemical risk to human health or the environment.

The specific objectives of the FS are as follows:

- Summarize findings and recommendations from the Revised Final Phase I RI Report, the Final Phase II RI Reports, and the supplemental risk evaluations;
- Identify areas with chemicals of concern (COCs) requiring remedial action and develop remediation goals;
- Identify, evaluate, and select the appropriate technologies for incorporation as components of the remedial alternatives;
- Perform a detailed and comparative analysis of alternatives using the threshold and balancing evaluation criteria established by USEPA; and
- Provide a recommended alternative for each site.

1.2 CONCLUSIONS OF THE REMEDIAL INVESTIGATION

The Revised Final Phase I RI Report and Phase II RI Reports prepared for FRBG, SRBG, and TRBG provide details regarding the historical site background, investigation results, and the human health risk assessment (HHRA) and ecological risk assessment (ERA) associated with each site (Leidos 2022a, 2022b, 2022c, and 2022d). The RI conclusions for each site are summarized below:

1.2.1 FRBG RI Conclusions

- The nature and extent of soil contamination at FRBG was adequately defined in accordance with CERCLA requirements. The FRBG Phase I RI focused mainly on soil contamination to address human health risk associated with hypothetical industrial and residential receptors and ecological risk.

- Several contaminant migration chemicals of potential concern (CMCOPCs) were identified in the fate and transport (F&T) evaluation, and further groundwater sampling and evaluation were recommended to be completed as part of the Phase II RI for groundwater.

- Neither the HHRA nor the ERA identified COCs requiring remediation. No further action regarding soil was required at FRBG.

- Various types of waste have been observed in FRBG, including a rusty steel drum and vertical pipe that is also recommended for removal and disposal. ACM was not detected in the 2 material samples collected. Asbestos sampling at FRBG indicated 1 out of 25 soil samples contained chrysolite asbestos at less than 1%. No other asbestos was detected. Based on sampling results, additional asbestos-containing material (ACM) assessment is not warranted. It was conservatively recommended to remove all asbestos contaminated soil at FRBG in lieu of additional site characterization to develop site-specific, risk-based action levels for asbestos per USEPA guidance (USEPA 2004). Therefore, asbestos contaminated soil will require assessment in an FS.

- Based on the Phase II RI results, FRBG groundwater has been adequately characterized, and further investigation is not warranted to complete the RI for groundwater. The nature and extent of potentially impacted media have been sufficiently characterized. Emerging contaminants will continue to be evaluated separately.

- The HHRA did not identify any COCs with residential use of groundwater at FRBG. Ecological exposures to chemicals in the groundwater is not a concern.

- NFA was recommended to address chemical contamination within soil at FRBG. Since no COCs were identified with residential use of groundwater at FRBG, NFA is also recommended for groundwater. However, it was recommended that the soil regional screening levels (RSLs) used in the Phase I RI be compared to current RSLs to determine if any additional COCs are present in surface and subsurface soils.

- Due to the nature of the site (former burning ground), Ohio EPA correspondence stated that if VOCs were not detected as potential COCs for the site, assessing the soil vapor pathway would not be triggered (Ohio EPA 2019). Vapor-forming chemicals were not identified as COCs in subsurface soils at FRBG as part of the Phase I RI or groundwater in Phase II. Evidence determined that soil vapor sampling was not warranted at FRBG.

1.2.2 SRBG RI Conclusions

- The nature and extent of soil contamination at SRBG was adequately defined in accordance with CERCLA requirements. The SRBG Phase I RI focused mainly on soil contamination to address human health risk associated with hypothetical industrial and residential receptors and ecological risk.

- Several CMCOPCs were identified in the F&T evaluation, and further groundwater sampling and evaluation were recommended to be completed as part of the Phase II RI for groundwater.

- While the HHRA identified several chemicals of potential concern (COPCs) in surface soil and one COPC in subsurface soil, only four COCs (polychlorinated biphenyl [PCB]-1248, PCB-1254, PCB-1260, and silver) were identified in surface soil at sample locations SRBG-SL-002, SRBG-SL-004, and/or SRBG-SL-009 for potential remedial action to be protective of future residential land use. No COCs were identified as requiring remedial action to be protective of future industrial land use.

- While the ERA identified several chemicals of potential ecological concern (COPECs) in surface soil, only five (cadmium; lead; mercury; PCB-1260; and 2,6-dinitrotoluene[DNT]) were identified in surface soil at sample locations SRBG-SL-001 and SRBG-SL-003 for potential remedial action to be protective of ecological receptors.

- Metal fragments, debris, and piping were identified southeast of the Primary Burn Area that is also recommended for removal and disposal. Two pieces of ACM (off-white transite at SRBG-DD-001 and SRBG-DD002) were considered friable and greater than 1% asbestos (chrysotile). However, there was only a small piece of this transite material at each location, and all identified material was removed for sampling. NFA was recommended for ACM. Four samples at SRBG had detectable asbestos in soil (SRBG-SL-001, SRBG-SL-002, SRBG-SL-003, and SRBG-SL-004). It was conservatively recommended to remove all asbestos contaminated soil at SRBG in lieu of additional site characterization to develop site-specific, risk-based action levels for asbestos per USEPA guidance (USEPA 2004). Therefore, asbestos contaminated soil will require assessment in an FS.

- SRBG groundwater has been adequately characterized, and further investigation is not warranted to complete the RI for groundwater. The nature and extent of potentially impacted media has been sufficiently characterized. Emerging contaminants will continue to be evaluated separately.

- The HHRA did not identify any COCs with residential use of groundwater at SRBG. Ecological exposures to chemicals in the groundwater is not a concern.

- Since no COCs were identified with residential use of groundwater at SRBG, no additional recommendations are warranted for the FS for groundwater. However, it was recommended that the soil RSLs used in the Phase I RI be compared to current RSLs to determine if any additional COCs are present in surface and subsurface soils and if the remedial cleanup goals in the FS need to be updated.

- Due to the nature of the site (former burning ground), Ohio EPA correspondence stated that if VOCs were not detected as potential COCs for the site, assessing the soil vapor pathway would not be triggered (Ohio EPA 2019). Vapor-forming chemicals were not identified as COCs in subsurface soils at SRBG as part of the Phase I RI or groundwater in Phase II. Evidence determined that soil vapor sampling was not warranted at SRBG.

1.2.3 TRBG RI Conclusions

- The nature and extent of soil contamination at TRBG was adequately defined in accordance with CERCLA requirements. The TRBG Phase I RI focused mainly on soil contamination to address human health risk associated with hypothetical industrial and residential receptors and ecological risk.

- Several CMCOPCs were identified in the F&T evaluation, and further groundwater evaluation were recommended to be completed as part of a subsequent Phase II RI for groundwater.

- While the HHRA identified several COPCs in surface soil and three COPCs in subsurface soil; only two COCs (PCB-1254 and PCB-1260) were identified for potential remedial action to be protective of future residential land use at sample locations TR-6, TRBG-SL-001, and TRBG-SL-002. Only one COC (PCB-1254) was identified as requiring remedial action to be protective of future industrial land use.

- The ERA for TRBG concluded that no further action was needed to be protective of any ecological receptors at SRBG.

- Metal fragments, debris, and piping were identified in the Debris Area. Although this area was not identified as having chemical contamination posing a risk to human health or the environment, it is recommended that the removal and disposal of this debris be included in site remedial activities. Remediation of the proposed locations for chemical COCs will also address the three surface soil sample locations (TRBG-SL-001, TRBG-SL-002, and TRBG-SDSW-004) that had detectable asbestos, as well as the area that contained the one piece of ACM (white cementitious material at TRBG-SL-001). Sample location TRBG-SDSW-004 had less than 1% asbestos. Sample location TRBG-SL-001 had 3.5% chrysotile in the soil. This location also had co-located ACM identified as white, cementitious material that contained 20% chrysotile which, given the size, was removed during sampling activities. Therefore, asbestos contaminated soil will require assessment in an FS.

- This Phase II RI only evaluated groundwater at TRBG, as soil was evaluated in the Phase I RI. Based on the Phase II RI results, TRBG groundwater has been adequately characterized, and further investigation is not warranted to complete the RI for groundwater. The nature and extent of potentially impacted media has been sufficiently characterized. Emerging contaminants will continue to be evaluated separately.

- The HHRA did not identify any COCs with residential use of groundwater at TRBG. Ecological exposures to chemicals in the groundwater is not a concern. NFA is required to address chemical contamination within groundwater at TRBG.

- Since no COCs were identified with residential use of groundwater at TRBG, no additional recommendations are warranted for the FS for groundwater. However, it was recommended that the soil RSLs used in the Phase I RI be compared to current RSLs to determine if any additional COCs are present in surface and subsurface soils and if the remedial cleanup goals in the FS need to be updated.

- Due to the nature of the site (former burning ground), Ohio EPA correspondence stated that if VOCs were not detected as potential COCs for the site, then assessing the soil vapor pathway would not be triggered (Ohio EPA 2019). Vapor-forming chemicals were not identified as COCs in subsurface soils at TRBG as part of the Phase I RI. Groundwater tested in Phase II of the RI showed different results. All four monitoring wells samples had low concentrations of VOCs. However, no detected chemicals were identified as COCs and it was determined that installation of vapor points and collection of soil vapor samples were not warranted at TRBG.

1.3 SUPPLEMENTAL RISK EVALUATION

Human health and ecological evaluations were conducted to determine if methods and/or soil screening values have changed since the soil RIs and FS were conducted in 2018 (Leidos 2022a). If methods and/or screening values changed, the impact of the changes to the risk assessment conclusions was also evaluated.

To evaluate the effects to human health risk, an analysis was conducted examining the impact of USEPA RSL changes to the human health soil COC selection and HHRA conclusions in the FRBG, SRBG, and TRBG soils RIs. The RIs were conducted in 2018 and some RSLs have changed since that time. The analysis was conducted by determining if updated RSLs cause new chemicals to become COPCs and then calculating the associated risks for those new chemicals. Three chemicals were identified as potential new soil COPCs (i.e., 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, and cadmium) and risks calculated for these chemicals. After examining the newly calculated risks and the existing cumulative risks, no new human health soil COCs were identified at any of the burning grounds. This analysis is provided in Appendix A.

To evaluate the effects to ecological risk, the 2008 and 2018 versions of the *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2008, 2018) were compared for substantive changes that could affect the conclusions of the previous RIs which were completed using the 2008 guidance. The only potential substantive change involved Ohio EPA eliminating the USEPA Region 5 *Ecological Screening Levels* as the third source of soil screening values from their selection hierarchy. However, Ohio EPA does not recommend a source replacement for the USEPA Region 5 ecological screening levels (ESLs) in their screening hierarchy. Given the conservative nature of the USEPA Region 5 ESLs, they were retained in the ERA re-evaluations. After examining the soil screening hierarchy and other smaller changes between the 2008 and 2018 guidance, which are discussed in more detail in Appendix A, there are no new ecological COPECs identified at any of the burning grounds. Note that the final COPECs identified in the RIs are labelled as ecological COCs in subsequent sections of this report.

1.4 REPORT ORGANIZATION

This report is organized in accordance with Ohio EPA and USEPA CERCLA RI/FS guidance. The following is a summary of the components of the report and a list of appendices:

- Section 2.0 outlines the development of RAOs for the chemicals and media of concern.
- Section 3.0 summarizes potential federal and state chemical-, location-, and action-specific applicable or relevant and appropriate requirements (ARARs) for potential remedial actions.
- Section 4.0 presents general response actions (GRA) and the identification and screening of technology types and process options considered for possible use in remediation.
- Section 5.0 develops remedial alternatives from technologies and process options that passed initial screening and presents an initial evaluation against effectiveness, implementability, and cost.
- Section 6.0 presents the detailed and comparative analyses of viable remedial action alternatives developed to address COCs in soil using the seven criteria specified by CERCLA guidance.
- Section 7.0 presents the conclusions of the FS and the recommended remedial alternative.
- Section 8.0 provides a list of references used to develop this report.
- Appendices:
    - Appendix A contains the supplemental risk evaluation.
    - Appendix B contains the Green and sustainable remediation (GSR) evaluation.
    - Appendix C contains the revised detailed cost estimate.

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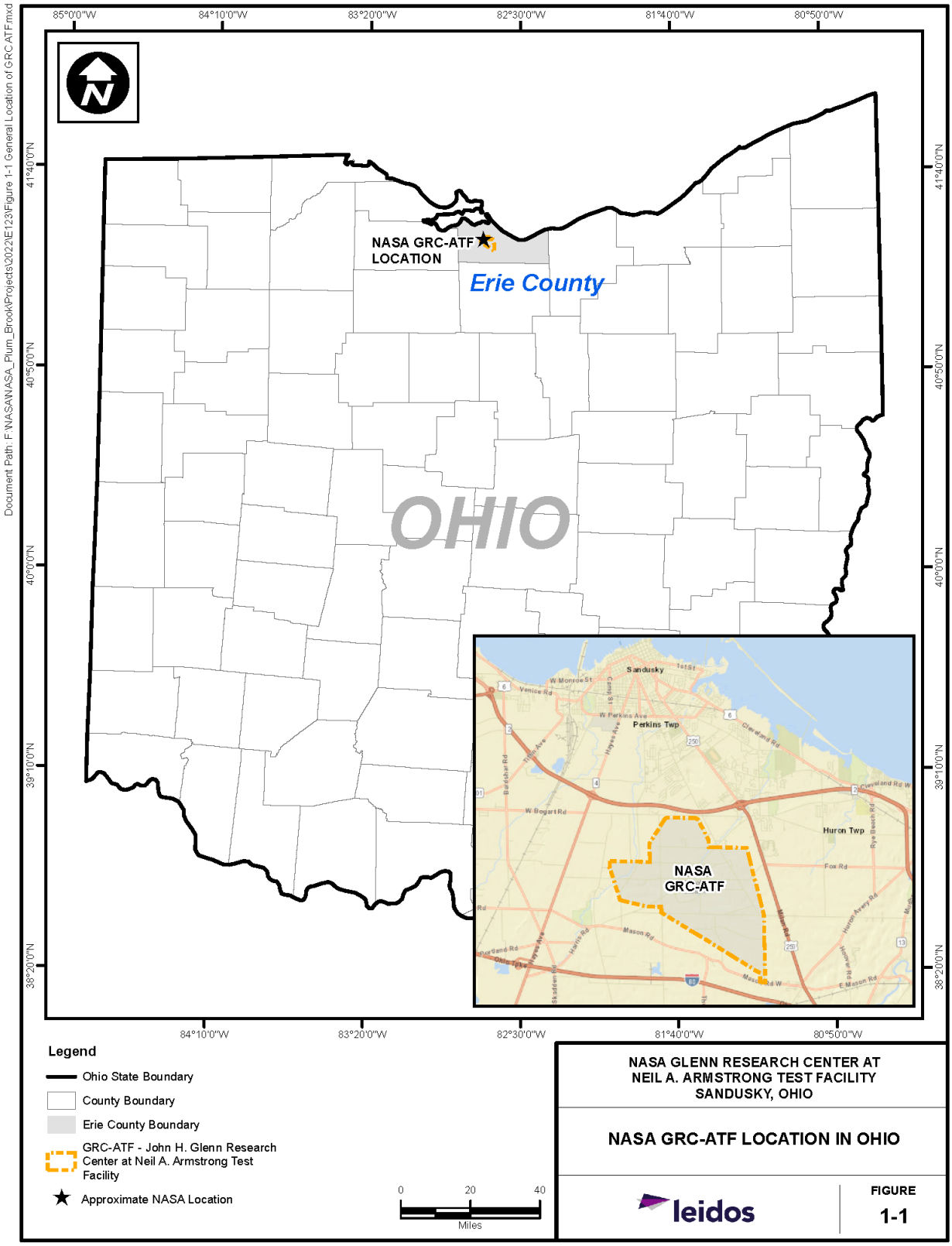

Figure 1–1. NASA GRC-ATF Location in Ohio

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2.0 REMEDIAL ACTION OBJECTIVES, CLEANUP GOALS, AND VOLUME CALCULATIONS

This section presents the RAOs, appropriate CUGs for remedial actions, and volume estimates of soil requiring remediation to protect human health and the environment and to attain specific land use scenarios at FRBG, SRBG, and TRBG. The RAOs are in accordance with NCP and CERCLA RI/FS guidance, which specify receptors, exposure routes, and desired exposure levels. CUGs establish acceptable exposure levels to be protective of human health and the environment while considering potential land uses and provide the basis for screening, evaluating, and selecting a remedial alternative.

2.1 FUTURE USE

The GRC-ATF facility is expected to remain under the control of NASA for the foreseeable future. FRBG, SRBG, and TRBG are best classified as inactive areas and plausible receptors include groundskeepers, construction workers, and hunters. Even though hunting is not currently permitted in these areas, hunting is permitted in other areas within GRC-ATF. It is highly unlikely that these sites will be developed for either commercial/industrial or residential purposes in the foreseeable future. However, per NASA's objective of attaining unrestricted reuse conditions at all three sites (i.e., suitable for residential land use), this FS primarily evaluated residential land use as the end goal in order to make appropriate risk management decisions.

2.2 REMEDIAL ACTION OBJECTIVE

The historical investigations detailed in the Revised Final Phase I RI Report (Leidos 2022a) concluded that no remediation is required at FRBG to be protective for human health or the environment. However, NASA has elected to remove all detectable asbestos at FRBG, SRBG, and TRBG rather than develop site-specific, risk-based action levels for asbestos per USEPA guidance (USEPA 2004). Areas of surface soil contamination at SRBG were identified as requiring remediation for the hypothetical industrial receptors and/or residential receptors and ecological resources (Leidos 2022a). Limited areas of surface and subsurface soil contamination at TRBG were identified as requiring remediation for the hypothetical industrial receptors and/or residential receptors (Leidos 2022a). The RAOs for FRBG, SRBG, and TRBG are as follows:

- FRBG – Remove all detectable asbestos in surface soil.

- SRBG – Reduce human health risk from potential exposure to COCs in surface soil to acceptable levels. Reduce ecological risk from potential exposure to COCs in surface soil to acceptable levels. The human health and ecological COCs are presented in Table 2-1. Achieve CUGs presented in Table 2-1 that are protective of future residential land use and ecological resources. Remove all detectable asbestos in surface soil.

- TRBG – Reduce human health risk from exposure to COCs in surface and subsurface soil presented in Table 2-1 to acceptable levels. Achieve CUGs presented in Table 2-1 that are protective of future residential land use. Remove all detectable asbestos in surface soil.

2.3 REMEDIAL ACTION CLEANUP GOALS

Table 2-1 presents the human health and ecological COCs at each site along with their associated cleanup goals. The table also shows the sample locations recommended for remediation.

The HHRA for SRBG and TRBG recommended CUGs for human health COCs be protective of residential receptors to support the remedial alternative selection process. For silver, the USEPA residential soil RSL of 195 mg/kg, which is equal to a target Hazard Quotient (HQ) of 0.5 (USEPA 2022), was selected as the cleanup goal as both silver and the PCB Aroclor 1254 both have documented non-cancer effects on the dermal system. For PCBs, the residential cleanup goal from USEPA's Guidance on Remedial Actions for Superfund Sites with PCB Contamination (USEPA 1990) was selected.

The ERA for SRBG recommended CUGs for ecological COCs be protective of ecological receptors that may be present at the site. In order to be conservative, ecological screening values (ESVs) were selected as CUGs for cadmium (0.36 mg/kg) and DNT (0.0328 mg/kg). The ESVs for lead (11 mg/kg) and mercury (0.00051 mg/kg) were within background soil concentrations. It is not recommended that risk-based CUGs be set within the range of background concentrations. As a result, the CUG for mercury (0.085 mg/kg) is based on the site-specific background criterion for NASA GRC-ATF. Lead was not a human health COC at SRBG, but it was at Firing Ranges 3 & 4 and ECCL. The human health CUG of 400 mg/kg was selected as the final CUG at Firing Ranges 3 & 4 and ECCL because it not only provided direct protection to human health but also provided secondary protection to ecological receptors. For consistency purposes across the NASA sites, 400 mg/kg also was selected as the lead CUG at SRBG. Use of 400 mg/kg as the CUG at SRBG would still result in removal of the three highest lead detections at SRBG in a similar manner to using the more conservative 48.6 mg/kg (background for NASA GRC-ATF) as the CUG. The maximum detected lead concentration of 410 mg/kg at SRBG-SL-003 would be removed using either CUG. The two other remaining high concentrations of 340 mg/kg lead at SRBG-SL-001 and 360 mg/kg at SRBG-SL-004 that would have been removed using the lower Eco CUG of 48.6 mg/kg will still be remediated because they are co-located with other COCs requiring remediation. The ESV for PCB-1260 used in the ERA was 0.371 mg/kg, which is protective of shrews (Efroymson, 1997). Assessments of PCB sites by the Department of the Interior have concluded that PCB concentrations of 1 - 2 milligram per kilogram (mg/kg) are protective of wildlife such as migratory birds (USEPA 1990). As 1 mg/kg is generally considered protective of wildlife and is the remedial clean up goals used for human health, this value was selected as the CUG for the SRBG EU.

In surface soil of the Primary Burn Area exposure area (EU) at the SRBG (Figure 2-2), PCB-1260 was detected in four of five samples. Three of these surface soil samples exceeded the PCB-1260 ESV of 0.371 mg/kg. These three samples are SRBG-SL-001 (0 to 2 ft below ground surface [bgs]) with a concentration of 0.82 mg/kg, SRBG-SL-003 (0 to 2 ft bgs) with a concentration of 0.77 mg/kg, and SRBG-SL-004 (0 to 2 ft bgs) with a concentration of 1.2 mg/kg. As noted in Table 2-1, the maximum detected concentration of 1.2 mg/kg will be remediated as part of the human health remediation at SRBG-SL-004. While use of a CUG of 1 mg/kg would not result in removal of any soil for PCB-1260 at SRBL-SL-001 and 003 because concentrations are already below 1 mg/kg, these two locations will be remediated for other ecological COCs as noted in Table 2-1 so use of a lower PCB-1260 CUG (i.e., 0.371 mg/kg) is not required.

Table 2–1. Cleanup Goals for FRBG, SRBG, and TRBG

Site	Medium	Sample Location(s)	Chemical of Concern (COC)		Remedial Cleanup Goal (mg/kg)	Basis for Cleanup Goal
			Human Health	Ecological		
FRBG	Soil	FRBG-SL-024	Asbestos	–	Non-detect (0%)	(5)
SRBG	Soil	SRBG-SL-002 SRBG-SL-004 SRBG-SL-009	PCB-1248	–	1	(1)
			PCB-1254	–	1	(1)
			PCB-1260	–	1	(1)
			Silver	–	195	(2)
			Asbestos	–	Non-detect (0%)	(5)
		SRBG-SL-001 SRBG-SL-003	–	Cadmium	0.36	(3)
			–	Lead	400	(2)
			–	Mercury	0.085	(4)
			–	2,6-Dinitrotoluene	0.0328	(3)
			–	PCB-1260	1	(1)
			Asbestos	–	Non-detect (0%)	(5)
TRBG	Soil	TRBG-SL-001 TRBG-SL-002 TRBG-SDSW-004 TR-6	Asbestos	–	Non-detect (0%)	(5)
			PCB-1254	–	1	(1)
			PCB-1260	–	1	(1)

mg/kg = Milligrams per kilogram
PCB = Polychlorinated biphenyl
FRBG = Fox Road Burning Ground
SRBG = Snake Road Burning Ground
TRBG = Taylor Road Burning Ground
Basis for cleanup goal:
(1) = USEPA Guidance on Remedial Actions for Superfund Sites (USEPA 1990)
(2) = Residential RSL, Noncarcinogenic screening level for a child (USEPA 2022)
(3) = Ecological screening value. The ESVs identified for use as CUGs were selected based on the following hierarchy: 1) lowest of the USEPA Ecological SSLs, 2) *PRGs for Ecological Endpoints* (Efroymson et al. 1997), and 3) USEPA Region 5 Ecological Screening Levels (2003).
(4) = NASA GRC-ATF background concentration
(5) = USEPA Guidance for Evaluating Asbestos at Superfund Cleanups (USEPA 2004)

2.4 VOLUME CALCULATIONS OF MEDIA REQUIRING REMEDIATION

The volumes of soil requiring remedial response action within FRBG, SRBG, and TRBG were calculated based on the lateral and vertical extent of soil containing one or more COCs above the CUGs presented in Table 2-1, or detectable asbestos. Figures 2-1 through 2-3 present the estimated extent of contamination requiring remediation for a residential receptor or ecological resource at FRBG, SRBG, and TRBG, respectively. The volumes presented in this section are estimates based on the available RI results. In the event that confirmation samples during remedial action determine CUGs are still exceeded, or asbestos is detected, the excavation footprint will be expanded, as appropriate, until the remedial CUGs are attained. In lieu of confirmation sampling during the remedial action, pre-excavation sampling may be conducted during the remedial design to fully define the excavation footprint prior to implementing the remedy.

The following general assumptions are made for estimating soil volumes for FRBG, SRBG, and TRBG:

- Vertical extent of remediation area
    - The excavation depth for contaminated soil is assumed to extend to the bottom of the depth interval that exhibited concentrations above the remedial CUG. For example, at SRBG the

maximum depth for excavation at exceedance location TRBG-SL-002 is assumed to be 6 ft bgs since the sample from the 2 to 6 ft bgs interval exceeded the remedial CUGs.

- Lateral extent of remediation area
    - Generally, the lateral extent of excavation was defined by half the distance between a sample with a human health CUG exceedance and an adjacent sample without a CUG exceedance. If no adjacent samples are available, the lateral extent was generally assumed to be 25 ft from the sample with the CUG exceedance.

The soil volume estimates for FRBG, SRBG, and TRBG are presented in Tables 2-2, 2-3, and 2-4, respectively.

Table 2–2. Estimated Soil Volume Requiring Remediation at FRBG

Fox Road Burning Ground (Sample location)	Depth bgs (ft)	Width (ft)	Length (ft)	Area (SF)	In-Situ		Tons[2]	Notes
					Volume (CY)	Volume with Constructability[1] (CY)		
Soil hotspot (FRBG-SL-024)	2	25	25	625	47	56	100	Hotspot extent based on detectable asbestos in soil at specific depth and location

[1]Constructability factor accounts for over excavation, sloping of sidewalls, and addresses limitations of removal equipment. The in-situ volume is increased by 20% for a constructability factor

[2]Assume density of soil at 1.8 tons/CY .

bgs = Below ground surface

COC = Chemical of concern

CY = Cubic yards

ft = Feet

FRBG = Fox Road Burning Ground

SF = Square feet

Table 2–3. Estimated Soil Volume Requiring Remediation at SRBG

Snake Road Burning Ground	Depth bgs (ft)	Width (ft)	Length (ft)	Area (SF)	In-Situ		Tons[2]	Notes
					Volume (CY)	Volume with Constructability[1] (CY)		
Soil hotspot (SRBG-SL-002)	2	75	75	5,625	417	500	900	HHRA COCs: PCBs and silver, hotspot extents based on PCB and silver exceedances at specific depths and locations Detectable asbestos in soil removal.
Soil hotspot (SRBG-SL-009)	2	75	75	5,625	417	500	900	
Soil hotspot (SRBG-SL-001)	2	75	75	5,625	417	500	900	ERA COCs: Cadmium; lead; mercury; PCB-1260; and 2,6-dinitrotoluene, hotspot extents based on PCB and silver exceedances at specific depths and locations Hot spot excavations-based COC exceedances at specific depths and locations. Detectable asbestos in soil removal.
Soil hotspot (SRBG-SL-003, SRBG-SL-004)	2	50	125	6,250	463	556	1,000	
			Subtotal	**23,125**	**1,712**	**2,056**	**3,700**	

[1]Constructability factor accounts for over excavation, sloping of sidewalls, and addresses limitations of removal equipment. The in-situ volume is increased by 20% for a constructability factor
[2]Assume density of soil at 1.8 tons/CY
bgs = Below ground surface.
COC = Chemical of concern
CY = Cubic yards
ERA = Ecological Risk Assessment
ft = Feet
HHRA = Human Health Risk Assessment
PCB = Polychlorinated biphenyl
SF = Square feet
SRBG = Snake Road Burning Ground

Table 2–4. Estimated Soil Volume Requiring Remediation at TRBG

Taylor Road Burning Ground	Depth bgs (ft)	Width (ft)	Length (ft)	Area (SF)	In-Situ		Tons[3]	Notes
					Volume (CY)	Volume with Constructability[1] (CY)		
Soil hotspot (TRBG-SL-002)	6	50	50	2,500	667[(2)]	800	1,440	COCs: PCBs Hotspot extents based on PCB exceedances at specific depths and locations. Detectable ACM and asbestos in soil removal.
Soil hotspot (TRBG-SL-001, TR-6)	2	50	125	6,250	463	556	1,000	
Soil hotspot (TRBG-SDSW-004)	2	30	70	2,100	156	187	336	
			Subtotal	**10,850**	**1,286**	**1,543**	**2,776**	

[1]Constructability factor accounts for over excavation, sloping of sidewalls, and addresses limitations of removal equipment. The in-situ volume is increased by 20% for a constructability factor

[2]Includes additional 20% soil for excavation slope at TRBG-SL-002.

[3]Assume density of soil at 1.8 tons/CY

bgs = Below ground surface
COC = Chemical of concern
CY = Cubic yards
ft = Feet
PCB = Polychlorinated biphenyl
SF = Square feet
TRBG = Taylor Road Burning Ground

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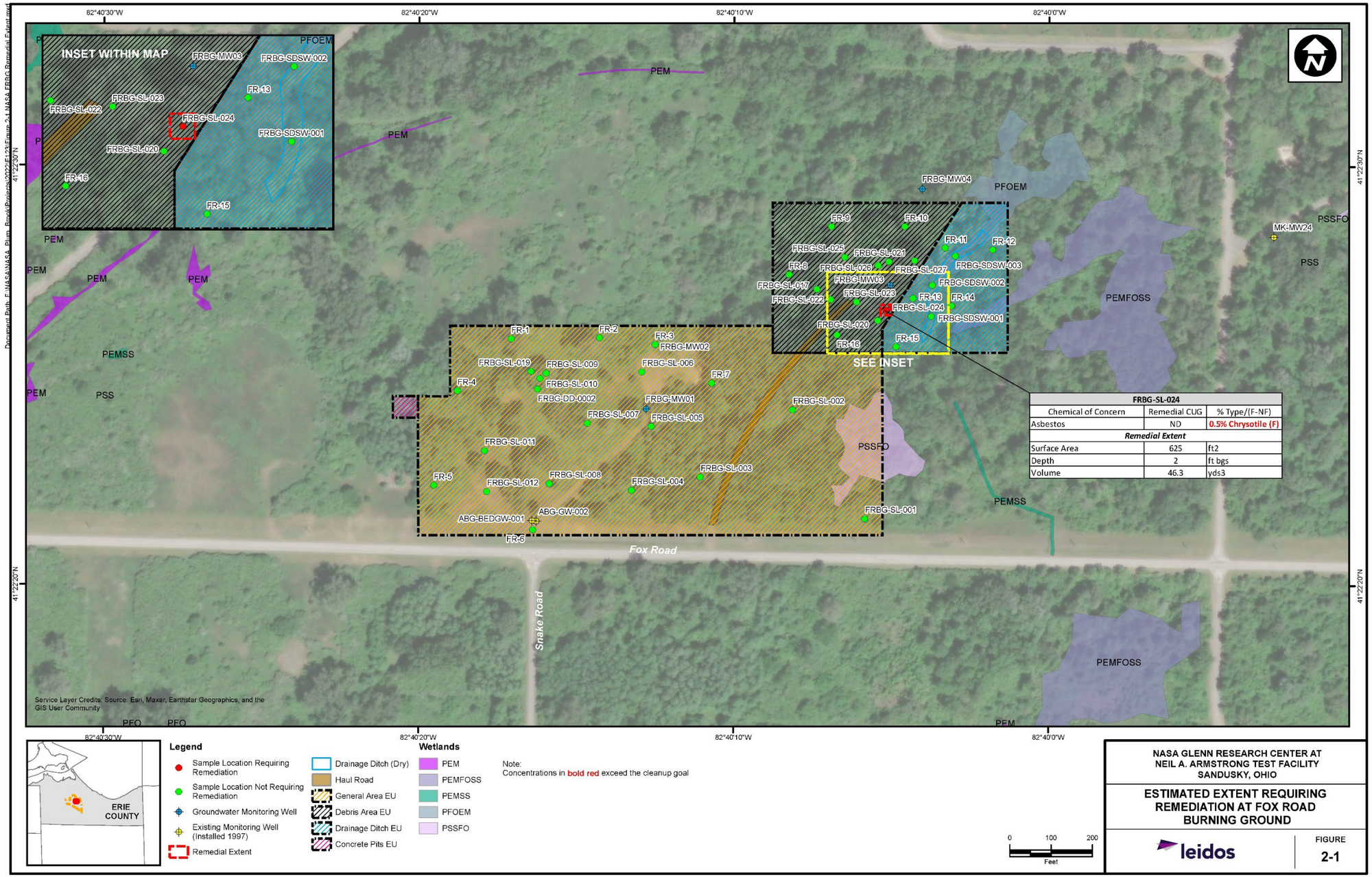

FRBG-SL-024		
Chemical of Concern	Remedial CUG	% Type/(F-NF)
Asbestos	ND	**0.5% Chrysotile (F)**
Remedial Extent		
Surface Area	625	ft2
Depth	2	ft bgs
Volume	46.3	yds3

Figure 2–1. Estimated Soil Extent Requiring Remediation at FRBG

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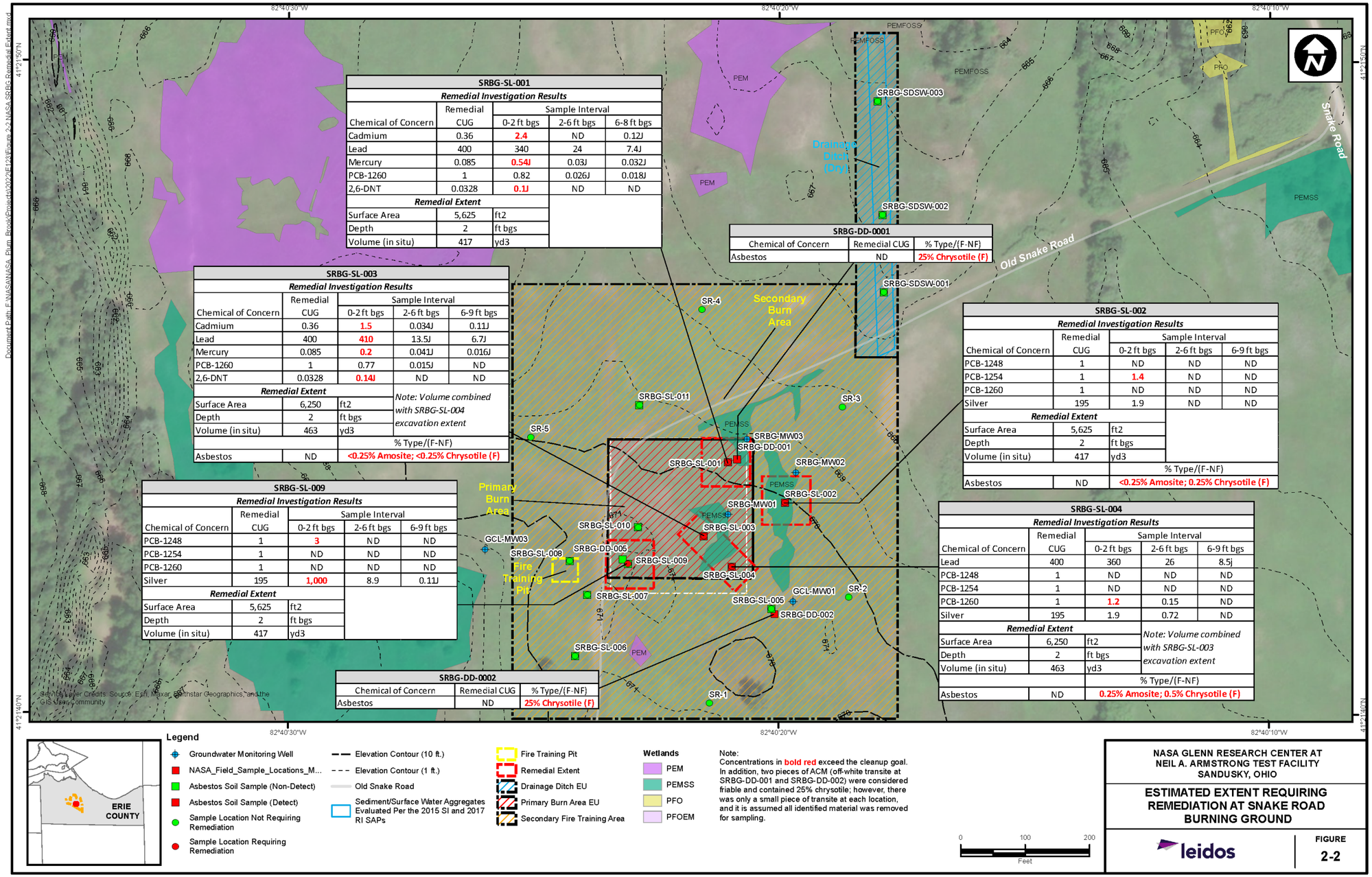

SRBG-SL-001

Remedial Investigation Results

Chemical of Concern	Remedial CUG	Sample Interval 0-2 ft bgs	2-6 ft bgs	6-8 ft bgs
Cadmium	0.36	**2.4**	ND	0.12J
Lead	400	340	24	7.4J
Mercury	0.085	**0.54J**	0.03J	0.032J
PCB-1260	1	0.82	0.026J	0.018J
2,6-DNT	0.0328	**0.1J**	ND	ND

Remedial Extent

Surface Area	5,625	ft2
Depth	2	ft bgs
Volume (in situ)	417	yd3

SRBG-DD-0001

Chemical of Concern	Remedial CUG	% Type/(F-NF)
Asbestos	ND	**25% Chrysotile (F)**

SRBG-SL-003

Remedial Investigation Results

Chemical of Concern	Remedial CUG	Sample Interval 0-2 ft bgs	2-6 ft bgs	6-9 ft bgs
Cadmium	0.36	**1.5**	0.034J	0.11J
Lead	400	**410**	13.5J	6.7J
Mercury	0.085	**0.2**	0.041J	0.016J
PCB-1260	1	0.77	0.015J	ND
2,6-DNT	0.0328	**0.14J**	ND	ND

Remedial Extent

Surface Area	6,250	ft2
Depth	2	ft bgs
Volume (in situ)	463	yd3

Note: Volume combined with SRBG-SL-004 excavation extent

	% Type/(F-NF)
Asbestos	ND	**<0.25% Amosite; <0.25% Chrysotile (F)**

SRBG-SL-002

Remedial Investigation Results

Chemical of Concern	Remedial CUG	Sample Interval 0-2 ft bgs	2-6 ft bgs	6-9 ft bgs
PCB-1248	1	ND	ND	ND
PCB-1254	1	**1.4**	ND	ND
PCB-1260	1	ND	ND	ND
Silver	195	1.9	ND	ND

Remedial Extent

Surface Area	5,625	ft2
Depth	2	ft bgs
Volume (in situ)	417	yd3

	% Type/(F-NF)
Asbestos	ND	**<0.25% Amosite; 0.25% Chrysotile (F)**

SRBG-SL-009

Remedial Investigation Results

Chemical of Concern	Remedial CUG	Sample Interval 0-2 ft bgs	2-6 ft bgs	6-9 ft bgs
PCB-1248	1	**3**	ND	ND
PCB-1254	1	ND	ND	ND
PCB-1260	1	ND	ND	ND
Silver	195	**1,000**	8.9	0.11J

Remedial Extent

Surface Area	5,625	ft2
Depth	2	ft bgs
Volume (in situ)	417	yd3

SRBG-SL-004

Remedial Investigation Results

Chemical of Concern	Remedial CUG	Sample Interval 0-2 ft bgs	2-6 ft bgs	6-9 ft bgs
Lead	400	360	26	8.5j
PCB-1248	1	ND	ND	ND
PCB-1254	1	ND	ND	ND
PCB-1260	1	**1.2**	0.15	ND
Silver	195	1.9	0.72	ND

Remedial Extent

Surface Area	6,250	ft2
Depth	2	ft bgs
Volume (in situ)	463	yd3

Note: Volume combined with SRBG-SL-003 excavation extent

	% Type/(F-NF)
Asbestos	ND	**0.25% Amosite; 0.5% Chrysotile (F)**

SRBG-DD-0002

Chemical of Concern	Remedial CUG	% Type/(F-NF)
Asbestos	ND	**25% Chrysotile (F)**

Figure 2–2. Estimated Soil Extent Requiring Remediation at SRBG

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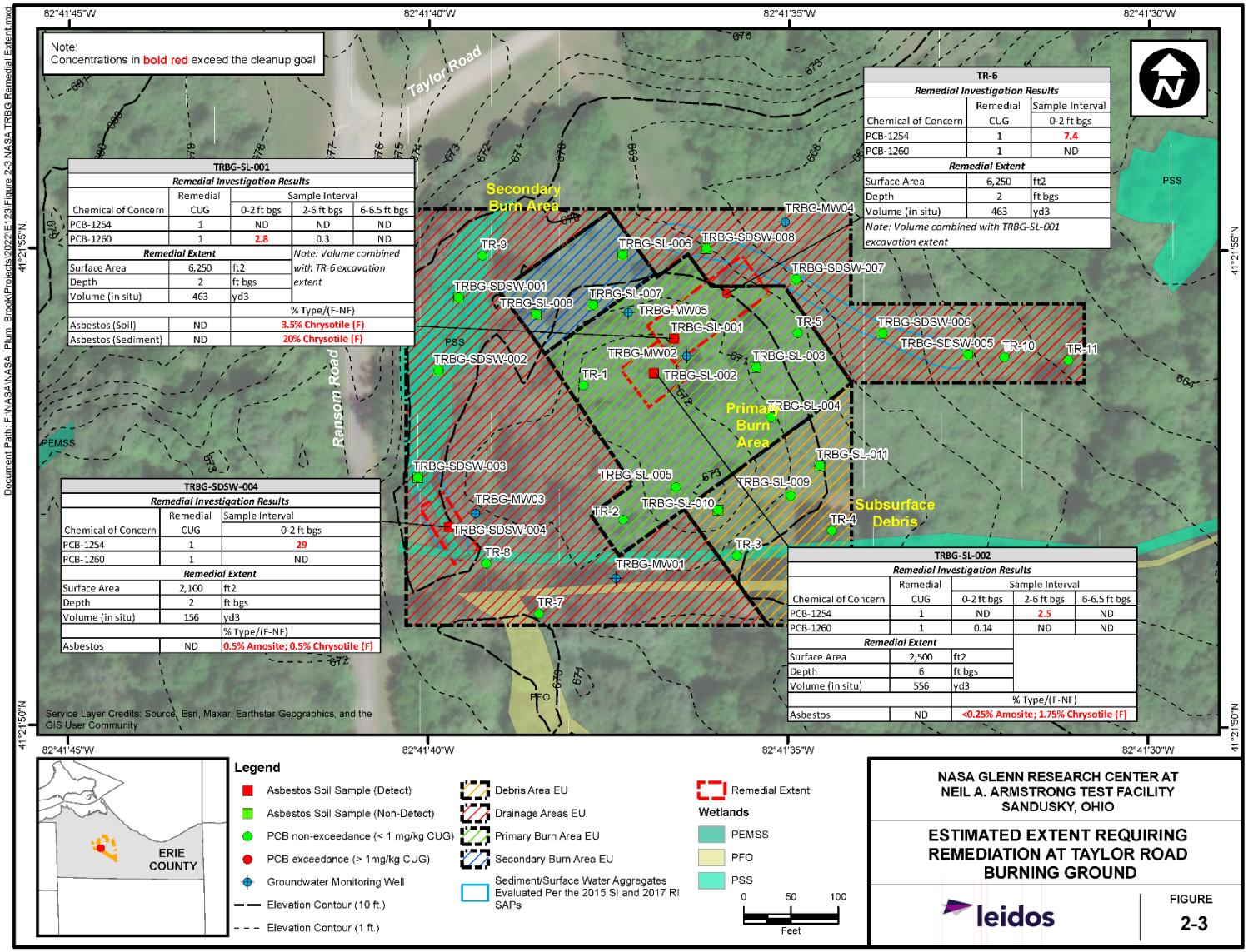

TRBG-SL-001

Remedial Investigation Results				
Chemical of Concern	Remedial CUG	Sample Interval 0-2 ft bgs	2-6 ft bgs	6-6.5 ft bgs
PCB-1254	1	ND	ND	ND
PCB-1260	1	**2.8**	0.3	ND
Remedial Extent				
Surface Area	6,250	ft2	*Note: Volume combined with TR-6 excavation extent*	
Depth	2	ft bgs		
Volume (in situ)	463	yd3		
		% Type/(F-NF)		
Asbestos (Soil)	ND	**3.5% Chrysotile (F)**		
Asbestos (Sediment)	ND	**20% Chrysotile (F)**		

TR-6

Remedial Investigation Results		
Chemical of Concern	Remedial CUG	Sample Interval 0-2 ft bgs
PCB-1254	1	**7.4**
PCB-1260	1	ND
Remedial Extent		
Surface Area	6,250	ft2
Depth	2	ft bgs
Volume (in situ)	463	yd3
Note: Volume combined with TRBG-SL-001 excavation extent		

TRBG-SDSW-004

Remedial Investigation Results		
Chemical of Concern	Remedial CUG	Sample Interval 0-2 ft bgs
PCB-1254	1	**29**
PCB-1260	1	ND
Remedial Extent		
Surface Area	2,100	ft2
Depth	2	ft bgs
Volume (in situ)	156	yd3
		% Type/(F-NF)
Asbestos	ND	**0.5% Amosite; 0.5% Chrysotile (F)**

TRBG-SL-002

Remedial Investigation Results				
Chemical of Concern	Remedial CUG	Sample Interval 0-2 ft bgs	2-6 ft bgs	6-6.5 ft bgs
PCB-1254	1	ND	**2.5**	ND
PCB-1260	1	0.14	ND	ND
Remedial Extent				
Surface Area	2,500	ft2		
Depth	6	ft bgs		
Volume (in situ)	556	yd3		
		% Type/(F-NF)		
Asbestos	ND	**<0.25% Amosite; 1.75% Chrysotile (F)**		

Figure 2–3. Estimated Soil Extent Requiring Remediation at TRBG

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3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

3.1 INTRODUCTION

CERCLA Section 121 specifies that remedial actions must comply with requirements or standards under federal or more stringent state environmental laws that are "applicable or relevant and appropriate to the hazardous substances or particular circumstances at the area of concern." In interpreting ARARs, it is inherently assumed that human health and the environment will be protected. This section summarizes potential federal and state chemical-, location-, and action-specific ARARs for potential remedial actions at FRBG, SRBG, and TRBG.

ARARs include federal and state regulations designed to protect human health and the environment. Applicable requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site" (40 CFR §300.5).

Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well suited to the particular site" (40 CFR §300.5).

In the absence of federal- or state-promulgated regulations, there are many criteria, advisories, guidance values, and proposed standards that are not legally binding, but may serve as useful guidance for setting protective cleanup levels. These are not potential ARARs but are to-be-considered (TBC) guidance [40 CFR §300.400(g)(13)].

CERCLA onsite remedial response actions must only comply with the substantive requirements of a regulation and not the administrative requirements. The definitions of "applicable" and "relevant and appropriate" require that federal or state requirements be substantive, i.e., cleanup standards, standards of control, and other substantive requirements, criteria, or limitations (40 CFR §300.5). Substantive is further defined in USEPA guidance as "those requirements that pertain directly to actions in the environment" (USEPA 1988). Administrative requirements are not considered ARARs and are described as those mechanisms of laws or regulations that facilitate implementation of the substantive requirements or methods or procedures by which substantive requirements are made effective. Certain administrative requirements should be observed if they are useful in determining cleanup standards at the site (Federal Register, Volume 55, page 8666). Offsite actions, on the other hand, are subject to the full requirements of the applicable standards or regulations, including all administrative and procedural requirements.

3.2 POTENTIAL ARARS

USEPA classifies ARARs as chemical-, action-, and location-specific to provide guidance for identifying and complying with ARARs (USEPA 1988).

- Chemical-specific ARARs are health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, allow numerical values to be established. These values establish the

acceptable amount or concentration of a chemical that may be found in or discharged to the ambient environment (USEPA 1988).

- Action-specific ARARs are rules, such as performance-, design-, or other activity-based rules that place requirements or limitations on actions.

- Location-specific ARARs are rules that place restrictions on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations (USEPA 1988).

3.2.1 Potential Chemical-Specific ARARs

In accordance with CERCLA §121(d)(2) requirements, no chemical-specific ARARs are applicable to FRBG, SRBG, and TRBG as there are no federal or state promulgated standards, requirements, or criteria that specify the degree of cleanup at these sites. However, the latest USEPA RSLs and ESVs discussed in the human health and ecological risk evaluations in the RI Reports for FRBG, SRBG, and TRBG are useful guidance for setting CUGs at FRBG, SRBG, and TRBG. The residential RSLs and ESVs are considered as TBC guidance. Sources for ESVs follow the hierarchy listed in the Ohio EPA guidance (Ohio EPA 2008).

PCB-contaminated soil at a site would be potentially regulated under the Toxic Substances Control Act (TSCA) based on the date of disposal, the concentration of original source material, and the current PCB concentration at the site. Based on the site history for SRBG and TRBG (detailed in their respective RI Reports), the contaminated soil with very low PCB concentrations at SRBG and TRBG does not qualify as PCB Remediation Waste, as defined in 40 CFR §761.3. Consequently, the TSCA regulations are not applicable for the PCB-contaminated soil at SRBG and TRBG.

As chemical-specific ARARs do not apply to FRBG, SRBG, and TRBG, the potential chemical-specific TBC guidance are detailed in Table 3-1.

3.2.2 Potential Action-Specific ARARs

Potential action-specific ARARs include the following:

- Potential excavation and disposal of contaminated soil would trigger potential ARARs associated with land disturbance and emission controls. Ohio Administrative Code (OAC) 3745-15-07 requires that nuisance air pollution emissions be controlled. This includes controlling potential fugitive dust from soil excavation and handling activities. In addition, any construction (i.e., soil disturbance activities that would encompass over 1 acre) would trigger the storm water requirements found at 40 CFR Part 450. These requirements mandate that erosion and sedimentation control measures be designed and implemented to control erosion and sediment runoff. Although the proposed removal action is not anticipated to disturb more than 1 acre, erosion controls and best management practices will be utilized during the potential removal action.

- Because excavation would include generating and managing contaminated environmental media and materials, Resource Conservation and Recovery Act (RCRA) requirements would be considered potential ARARs for this activity. The RCRA requirements mandate that a generator must determine whether a material is (or contains in the case of environmental media) hazardous waste under OAC 3745-52-11. If a material is determined to be or contain a listed hazardous waste, or exhibits a hazardous waste characteristic, additional management requirements under RCRA must be followed as an ARAR under CERCLA. If the excavated soil is determined to be characteristically hazardous and requires treatment or stabilization to render it non-hazardous for disposal, the requirements under OAC 3745-52-34 would be applicable. OAC 3745-52-17 specifies that generators are allowed to treat and

accumulate waste onsite up to 90 days without requiring a hazardous waste permit from Ohio EPA. Treatment as defined in OAC 3745-50-10(A) includes any method, technique, or process designed to change the physical, chemical, or biological composition of the waste to render the waste non-hazardous or less hazardous.

- The removal of ACM encountered in the burning grounds will also trigger the requirements of OAC 3745-20-01 through 3745-20-05 as ARARs for asbestos emission control, demolition procedures, and standards for asbestos waste handling and disposal. Requirements under OAC 3745-22 would also be applicable to ensure that removal, handling, and disposal of ACM is conducted under the supervision of an appropriately licensed Asbestos Hazard Abatement Specialist. These regulations require that wastes containing asbestos must be handled in a manner to prevent fugitive emissions from waste handling and must be transported to disposal in a sealed or contained manner (either sealed containers or transported in bulk by leak-tight transport vehicles or containers as required by subparagraph (B)(2) of the above referenced rule. In addition, a relevant and appropriate requirement can be invoked for this activity under OAC 3745-20-07(A)(1-3) to ensure either: (1) no visible emissions are discharged to the outside air; (2) asbestos-containing waste material is covered with at least 6 inches of compacted non-ACM, and a cover of vegetation is grown and maintained on the area to adequately prevent exposure of the asbestos-containing waste material; or (3) the asbestos-containing waste material is covered with at least 2 feet of compacted non-ACM, and the cover is maintained to prevent exposure of the asbestos-containing waste material.

- Shipments of contaminated soils and materials will comply with federal, state, and local rules, laws, and regulations. In addition to the identified ARARs for the selected action, NASA will comply with requirements applicable to offsite actions, including RCRA hazardous waste transportation requirements under OAC 3745-52-20 through OAC 3745-52-33, offsite treatment prior to land disposal as required by RCRA's land disposal restrictions (LDRs) under OAC 3745-270, and alternative LDR treatment standards for contaminated soil under OAC 3745-270-49.

- In the event solid waste material is found to be contaminated but not a RCRA hazardous waste, management and disposal of this material would be subject to the requirements associated with managing and disposing solid waste within the state of Ohio. OAC Section 3745-27-05 requirements would be potential ARARs for disposing non-hazardous contaminated waste material generated during excavation and subsequent disposal at an offsite location.

Potential action-specific ARARs are detailed in Table 3-2.

3.2.3 Potential Location-Specific ARARs

Potential location-specific ARARs include, but are not limited to, those requirements established for potential remedial activities conducted within wetlands, within a floodplain area, or with respect to federal- or state-listed species. Generally, for wetlands and floodplains, alternatives are required to be developed to conduct remedial activities outside the sensitive area; if that is not feasible, adverse effects from any actions taken within the sensitive area must be mitigated to the extent possible. These requirements do not relate to specific chemicals, nor do they change the degree of cleanup in the sense of protecting human health or the environment from the effects of harmful substances. Rather, their purpose is to protect sensitive areas to the extent possible. Under CERCLA Section 121(d), relevance and appropriateness are related to the circumstances presented by the release of hazardous substances, with the goal of attaining a degree of cleanup and controlling further releases to ensure protection of human health and the environment.

- FRBG is not within a floodplain area. The three wetlands (classified as Category 2) are at or very near the eastern boundaries of the General Area and Drainage Ditch (EnviroScience 2017). One of the three

wetlands (wetland 1) is associated with a wet weather ditch in the Drainage Ditch EU on the northeastern side of the site that was dry during the 2015 SI and 2017 RI. There are no streams or ponds at the site.

Due to the presence of sensitive resources (i.e., wetlands) within FRBG, if any remedial activities affect these wetlands, Executive Order 11990 (40 CFR 6, Appendix A) and OAC 3745-1-54 would be TBC guidance for the site. In that event, the following actions should be taken during the design and implementation of remedial actions: (a) Identify potential wetland impacts (e.g., impact to water quality, impact to habitat quality, or impact to vegetative community, etc.) and (b) Avoid wetland and water impacts where practicable, minimizing potential impacts to wetlands and water, and compensate for any remaining, unavoidable impacts to wetlands or waters through activities to enhance or create wetlands and/or waters.

- SRBG is not within a floodplain area. Small wetlands exist within the site boundary; however, no permanent surface water is present. Surface drainage flows over preferential pathways and into the drainage ditch located on the eastern portion of the site. The drainage ditch at SRBG is routinely dry and appears to be active only during events of significant precipitation resulting in runoff that flows northward to Lindsley Ditch.

  Due to the presence of sensitive resources (i.e., wetlands) within SRBG proposed remedial extents, any remedial activities that affect these wetlands are subject to TBC guidance, Executive Order 11990 (40 CFR 6, Appendix A) and OAC 3745-1-54. In that event, the following actions should be taken during the design and implementation of remedial actions: (a) determine if jurisdictional wetlands are present within the remedial area (b) Identify potential wetland impacts (e.g., impact to water quality, impact to habitat quality, or impact to vegetative community, etc.) and (c) Avoid wetland and water impacts where practicable, minimizing potential impacts to wetlands and water, and compensate for any remaining, unavoidable impacts to wetlands or waters through activities to enhance or create wetlands and/or waters.

  If jurisdictional wetlands are identified within the proposed remedial extents, permits and notifications are not required. Nationwide Permit 38 states "Activities undertaken entirely on a CERCLA site by authority of CERCLA as approved or required by EPA, are not required to obtain permits under Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act." Any disturbed area within a jurisdictional wetland will be restored with a NASA-approved wetland seed mixture.

  While rare plant species and threatened and endangered (T&E) species have been identified at SRBG, no rare plant species or T&E species are identified in the areas targeted for potential removal action. However, any remedial actions must be conducted in accordance with requirements established under the Endangered Species Act (16 United States Code 1531 *et seq.*, 50 CFR Parts 200 and 402) and the Ohio Revised Code (ORC) 1518 and 1525, even though these laws and rules do not establish standards, requirements, limitations, or criteria relating to the degree of cleanup for chemicals remaining on site at the close of the response actions.

- TRBG is not within a floodplain area. A small ephemeral wetland area (drainage ditch) exists along the western boundary of the site. No rare plant species and T&E species have been identified at TRBG.

  Due to the presence of sensitive resources (i.e., wetlands) within TRBG proposed remedial extents, any remedial activities that affect these wetlands are subject to TBC guidance, Executive Order 11990 (40 CFR 6, Appendix A) and OAC 3745-1-54. In that event, the following actions should be taken during the design and implementation of remedial actions: (a) determine if jurisdictional wetlands are present within the remedial area (b) Identify potential wetland impacts (e.g., impact to water quality, impact to

habitat quality, or impact to vegetative community, etc.) and (c) Avoid wetland and water impacts where practicable, minimizing potential impacts to wetlands and water, and compensate for any remaining, unavoidable impacts to wetlands or waters through activities to enhance or create wetlands and/or waters.

If jurisdictional wetlands are identified within the proposed remedial extents, permits and notifications are not required. Nationwide Permit 38 states "Activities undertaken entirely on a CERCLA site by authority of CERCLA as approved or required by EPA, are not required to obtain permits under Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act." Any disturbed area within a jurisdictional wetland will be restored with a NASA-approved wetland seed mixture.

Any action taken by the federal government must be conducted in accordance with the requirements established under the National Environmental Policy Act, Endangered Species Act, Migratory Bird Treaty Act, Section 106 National Historic Preservation Act, Native American Graves Protection and Repatriation Act, state burial laws, and federal and state wetlands and floodplains construction and placement of materials considerations, even though these laws and rules do not establish standards, requirements, limitations, or criteria relating to the degree of cleanup for chemicals remaining on site at the close of the response actions.

Potential location-specific ARARs are detailed in Table 3-3.

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Table 3–1. Potential Chemical-Specific To-Be-Considered Guidance

Standard, Requirement, and Citation	Description of Requirement	Potential Status and Type	Comments
Federal Authority Level ARARs			
Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1998) Regional Screening Levels (USEPA 2022)	Residential RSVs	To-Be-Considered	All soil subject to remediation based on cleanup goals determined using human health risk-based screening criteria.
Toxic Substance Control Act (TSCA); 40 CFR 761	Regulates the handling of PCBs and contains certain chemical-specific cleanup levels (e.g., TSCA residential exposure standard of 1 mg/kg for total PCBs in soil).	To-Be-Considered	All PCB-impacted soil and waste generated will be handled as per the requirements of TSCA.
State Authority Level ARARs			
Guidance for Conducting Ecological Risk Assessments (DERR-00-RR-31) Ohio EPA 2008	Residential ESVs	To-Be-Considered	All soil subject to remediation based on cleanup goals determined using ecological risk-based screening criteria.
Ohio State Generic Numerical Standards; OAC 3745-300	Establishes residential and non-residential health-based standards based on ingestion/dermal or inhalation pathway. Note: Inhalation pathway standards are Not Applicable or Relevant and Appropriate.	To-Be-Considered	The selected remedy will comply with these requirements by eliminating the COCs direct contact pathway.

Note: There are no potential chemical-specific ARARs for any of the COCs.

Table 3–2. Potential Action-Specific ARARs

Standard, Requirement, and Citation	Description of Requirement	Potential ARAR Status and ARAR type	Comments
Federal Authority Level ARARs			
Standards Applicable to Generation of Hazardous Waste; 40 CFR Part 262	Establishes standards for generators of hazardous waste under RCRA. Specifies requirements for hazardous waste packaging, labeling, manifesting, record keeping, and accumulation time.	Applicable	Standards will be followed if any hazardous wastes are generated onsite.
Clean Air Act (CAA) – National Ambient Air Quality Standards (NAAQs); 40 CFR 50	These provide air quality standards for particulate matter, lead, NO2, SO2, CO, and volatile organic compounds.	Applicable	During all remedial activities, air emissions will be properly controlled and monitored to comply with these standards.
State Authority Level ARARs			
Prohibition of air pollution nuisances (e.g., fugitive dust); OAC Section 3745-15-07	These rules prohibit releasing nuisance air pollution that endangers health, safety, or welfare of the public or cause personal injury or property damage. This would include dust from excavation or soil management processes.	Applicable	During all remedial activities, air pollution nuisances will be properly controlled and monitored.
Generation of contaminated soil or debris; OAC Section 3745-52-11	These rules require that a generator determine whether a material generated is a hazardous waste. Must be characterized to determine whether the material is or contains a hazardous waste	Applicable	During all remedial activities, air pollution nuisances will be properly controlled and monitored.
Management of contaminated soil or debris that is or contains a hazardous waste; OAC Sections 3745-52-30 through 3745-52-17	These rules require that hazardous waste be properly packaged, labeled, marked, and accumulated onsite pending on or offsite disposal.	Applicable	All hazardous waste will be accumulated in a compliant manner that includes proper marking, labeling, and packaging in accordance with the specified regulations. This includes inspecting containers or container areas where hazardous waste is accumulated onsite.
NPDES Requirement for Stormwater Management at Construction Sites; OAC Section 3745-39-04	Establishes requirements for a stormwater discharge permit for construction activities that disturb greater than one acre of land.	Not Applicable	Excavation area is currently planned to be less than one acre.

Table 3–2. Potential Action-Specific ARARs (continued)

Standard, Requirement and Citation	Description of Requirement	Potential ARAR Status and ARAR type	Comments
Soil contaminated with RCRA hazardous waste; OAC Section 3745-270-49 OAC Section 3745-270-48 UTS	These rules prohibit land disposal of RCRA hazardous wastes subject to them, unless the waste is treated to meet certain standards that are protective of human health and the environment. Standards for treating hazardous waste-contaminated soil prior to disposal are set forth in the two cited rules. Using the greater of either technology-based standards or UTS is prescribed.	Applicable.	All soil subject to treatment will be treated to achieve a 90% constituent reduction standard on a constituent-specific basis as detailed in the rule.
Asbestos Emission Control; OAC Sections 3745-20-01 through 3745-20-05 OAC Section 3745-20-22	These rules established the standards for asbestos waste handling, including that it is conducted under the supervision of an appropriately licensed Asbestos Hazard Abatement Specialist.	Applicable	Applies to any activity that could result in discharge of visible emissions to the outside air during the collection, processing, packaging, transporting, or deposition of any asbestos-containing waste material.
Safety and Health Regulations for Construction; 29 CFR 1926.1101 Asbestos	Regulates asbestos exposure in during construction activities including transportation and disposal of asbestos containing material	Applicable	All construction activities will comply with these requirements by implementing work practices to control workers' exposure.
Asbestos Emission Control OAC 3745-20-03, OAC 3745-22-04(C)(4), and 40 CFR 61.145(b)	These rules establish that notification is required to the Ohio EPA Central Office – Division of Air Pollution Control a minimum of 10 working days before the remedial action ("abatement") begins. "Abatement" refers to any asbestos hazard abatement activity involving the removal, renovation, enclosure, repair, or encapsulation of reasonably related friable ACMs in an amount greater than 50 linear feet or 50 square feet.	Applicable	Discharge of visible emissions to the outside air is prohibited during asbestos waste handling.

ACM = Asbestos-containing material
ARAR = Applicable and Relevant or Appropriate Requirements
CFR = Code of Federal Regulations
EPA = Environmental Protection Agency
LDR = Land disposal restrictions
OAC = Ohio Administrative Code
RCRA = Resource Conservation and Recovery Act
UTS = Universal Treatment Standard

Table 3–3. Potential Location-Specific ARARs

Standard, Requirement, Criteria, or Limitation	Media and Citation	ARAR Status and Type	Comments
Federal Authority ARARs			
Endangered Species Act; 16 USC 1531 50 CFR Parts 200 and 402	Requires action to conserve threatened or endangered species, including consultation with the Department of Interior.	Applicable	Threatened or endangered species were observed within the property boundary. However, no endangered species were observed within the boundary of proposed remedial action. The remedy will comply with the Act if endangered species are found during remedial activities.
National Historical Preservation Act; 16 USC 470 Section 106 16 USC 469 43 CFR 7	Requires federal agencies to assess the site for potential historical structures or artifacts. These properties shall be preserved for future generations of Americans.	Applicable	The potential effects of any remedial action will be evaluated to ensure that these requirements are met.
Migratory Bird Treaty Act; 16 USC 703	The selected remedial action(s) must be executed in a manner that avoids the taking or killing of protected migratory bird species, including individual birds or their nests or eggs.	Applicable	The potential effects of any remedial action will be evaluated to ensure that these requirements are met.
Protection of Wetlands; 44 CFR Part 9, Executive Order 11990	Federal agencies are directed to avoid construction located in wetlands unless the agency head finds: (1) No practical alternative to such construction and The proposed action includes all practical measures to minimize harm to wetlands which might result from such use.	Applicable	The potential effects of any remedial action will be evaluated to ensure that these requirements are met.
Protection of Wetlands; 40 CFR 230, 33 USC 1344, CWA Section 404, Section 10 of the Rivers and Harbors Act	Sets forth guidelines for fill material in wetlands. Requires federal agencies to avoid impacts associated with the destruction or loss of wetlands.	Applicable	Backfilling excavated wetland soil is expected to be part of the remedy. These guidelines will be met during the remedial activities.
Wetlands Permitting; 32 CFR 650.68	Identifies permitting requirements for excavation activities in wetlands.	Applicable	This requirement will be met before commencement of remedial activities.

Table 3–3. Potential Location-Specific ARARs (continued)

State Authority ARARs			
Ohio T&E Species Conservation; Ohio Revised Statute 1518 and 1532	Requires action to conserve state-listed threatened or endangered species.	Applicable	Threatened or endangered species were observed within the property boundary. However, no endangered species were observed within the boundary of proposed remedial action. The remedy will comply with the Statute if endangered species are found during remedial activities.
Wetland Antidegradation; OAC 3745-1-54	This establishes requirements to minimize potential adverse impacts on wetlands	Applicable	The potential effects of any remedial action will be evaluated to ensure that these requirements are met.

ARAR = Applicable and Relevant or Appropriate Requirements
CFR = Code of Federal Regulations
CWA = Clean Water Act
T&E = Threatened and Endangered
USC = United States Code

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4.0 TECHNOLOGY TYPES AND PROCESS OPTIONS

This section identifies and describes GRAs that may be implemented to achieve CUGs. In addition, this section summarizes the remedial technologies and process options available to remediate COCs in soil as identified in Section 5.0.

The procedure for identifying and screening potential remedial technologies followed the method established in the USEPA guidance document, *Guidance for Conducting Remedial Investigation/Feasibility Studies Under CERCLA* (USEPA 1988). This guidance document provides the framework for identifying and screening all available remedial technologies with the most appropriate technologies available based on the COCs and site characteristics from FRBG, SRBG and TRBG (e.g., soil type). Additional EPA guidance was also utilized for evaluating the potential remedial technologies applicable for PCB contamination in soil (USEPA 2012b).

4.1 GENERAL RESPONSE ACTION

GRAs are actions that may be implemented to satisfy RAOs associated with chemical contamination in soil. These actions may be individual or a combination of responses. The HHRA for SRBG identified PCBs and metals above remedial CUGs while the HHRA for TRBG identified PCBs above remedial CUGs. All three sites have detectable asbestos in soil. The following GRAs are applicable to FRBG, SRBG, and TRBG:

- No action;
- Institutional controls;
- Containment;
- Removal; and
- Treatment.

4.1.1 No Action

The NCP requires no action to be included as an alternative. The no action GRA is evaluated as the baseline to which other remedial alternatives are compared. No action may be an appropriate alternative if no unacceptable risk is present at a site. This GRA provides a baseline against which to compare other more proactive alternatives. In this alternative, no action would be taken at FRBG, SRBG, or TRBG to reduce any risk to human health or the environment. Any existing actions, such as land use restrictions or monitoring, would be discontinued.

4.1.2 Institutional Controls

Institutional controls include engineering measures (i.e., fencing, impermeable caps, warning signs, etc.) and non-engineering measures, such as administrative or legal controls, used to prevent or limit exposure to hazardous substances. Institutional controls do not reduce contaminant mobility, volume, or toxicity.

If institutional controls are selected as a component of a remedial alternative, the effectiveness of the remedy must undergo 5-year reviews. The primary goal of these reviews is to evaluate the implementation and performance of the remedy to determine if the remedy is or will be protective of human health and the environment. The 5-year reviews are discontinued when the remedy achieves CUGs for residential land use.

4.1.3 Containment

Containment technologies are often used to prevent, or significantly reduce, the migration of contaminants in soil or sediment. In general, containment is performed when extensive subsurface contamination at a site precludes excavation and removal of wastes because of potential hazards, technical impracticality, and/or unrealistic cost.

The main advantage of containment methods is that they can prevent further migration of contaminant plumes by minimizing infiltration and leaching. An institutional control is required to accompany the containment alternative, if implemented. Containment also requires periodic inspections for leaks and ponding of liquids, and periodic sampling to confirm the integrity of the containment system.

Common types of containment technologies include capping (e.g., clay cap, multi-layered cap that includes clay and synthetic liners, or an asphalt or concrete cap) and soil covers.

4.1.4 Removal

Removing contaminated soil from FRBG, SRBG, and TRBG would reduce or eliminate the potential for long-term human and environmental exposure to chemicals exceeding concentrations determined to be protective for a given land use. Removed soil may or may not undergo pre-treatment prior to offsite disposal.

Disposal and handling, after removal, involve the final and permanent placement of waste material in a manner protective of human health and the environment. The impacted media could be disposed offsite in a permitted or licensed facility such as a regulated landfill. Similarly, concentrated waste resulting from treatment processes could be disposed offsite in an approved disposal facility.

Transportation is accomplished utilizing various methods, including truck and/or railcar.

4.1.5 Treatment

Treatment is conducted either in-situ or ex-situ to reduce contaminant concentrations to acceptable levels. Common types of treatment include biological, chemical, physical, and thermal. Biological treatment involves using microbes to degrade contaminants. Chemical treatment processes add chemicals to react with contaminants to reduce their toxicity or mobility. Physical processes involve either physically binding the contaminants to reduce mobility or the potential for exposure (e.g., encapsulation) or extracting the contaminant(s) from a medium to reduce volumes. Thermal treatment, such as incineration, uses high temperatures to volatilize, decompose, or melt contaminants. For soil treated by ex-situ methods, the treatment may allow soil to be placed back into the excavation, or soil may be treated to reduce the chemical concentration or stabilize the soil prior to offsite disposal.

4.2 INITIAL SCREENING OF TREATMENT TECHNOLOGIES

Table 4-1 summarizes the remedial technologies and process options available for treating COCs in surface and subsurface soil at FRBG, SRBG, and TRBG. The initial screening focuses on technology types capable of remediating COCs present at the three sites and evaluates the implementability of the technology. If treatment technologies are evaluated and retained as potentially viable treatment options, the retained technology will undergo a more detailed evaluation described in Section 4.3.

4.3 DETAILED SCREENING OF TECHNOLOGIES

The remedial action technologies retained from the initial screening process are evaluated against criteria of effectiveness, implementability, and cost (three of the NCP balancing criteria). The rationale for either retaining or eliminating treatment options for the three sites is presented and summarized in Table 4-2. The remedial options retained from the detailed screening process used to develop the remedial alternatives are presented in Section 5.0.

4.3.1 Effectiveness

The effectiveness criterion assesses the ability of a remedial technology to protect human health and the environment by reducing the toxicity, mobility, or volume of contaminants. Each technology is evaluated for its ability to achieve RAOs, potential impacts to human health and the environment during construction and implementation, and overall reliability of the technology.

4.3.2 Implementability

Each process option/technology is evaluated for implementability in terms of technical feasibility, administrative feasibility, and availability of the necessary material, equipment, and work force. The assessment considers each technology's short- and long-term implementability. Short-term implementability considers constructability of the remedial technology, near-term reliability, the ability to obtain necessary approvals with other agencies, and the likelihood of obtaining a favorable community response. Long-term implementability evaluates the ease of undertaking additional remedial actions (if necessary), monitoring the effectiveness of the remedy, and operations and maintenance (O&M).

4.3.3 Cost

The cost criterion evaluates each remedial process in terms of relative capital and O&M costs. Costs for each technology are rated qualitatively, on the basis of engineering judgment, in terms of low, medium, or high cost.

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Table 4–1. Initial Screening of Technologies

General Response Actions	Technology Type	Process Options	Description	Screening Results
No Action	None	None	No action would be taken at FRBG, SRBG, and TRBG. Any current LUCs, access restrictions, and monitoring programs would be discontinued. No remedial technologies would be implemented to reduce hazards to potential human or ecological receptors.	Retained. Required under NCP to be carried through CERCLA analysis.
Institutional Controls	Access Restrictions	LUCs with CERCLA 5-Year Reviews	Implement LUCs at FRBG, SRBG, and TRBG to restrict access and land use for commercial/industrial purposes. LUCs will be administered, enforced, and reviewed in CERCLA 5-year reviews. These reviews include reviewing sampling and monitoring plans and results of monitoring activities, conducting interviews and inspections, and reviewing status.	Not retained. LUCs will inhibit intended objective of attaining unrestricted reuse (i.e., residential land use) for both sites.
		Fencing	Place fencing around areas of contamination (at a minimum) to restrict access and exposure to contamination left in place.	Not retained. Fencing will inhibit intended objective of attaining unrestricted reuse (i.e., residential land use) for both sites.
Containment	Capping	Asphalt/Concrete	Asphalt or concrete layers are used to cover contamination and prevent exposure. Additionally, this technology limits water infiltration; however, it is susceptible to cracking if not properly maintained.	Not retained. Using engineering controls (asphalt/concrete cap) in areas with contamination will inhibit intended objective of attaining unrestricted reuse (i.e., residential land use) for both sites.
Removal	Bulk Removal	Excavation and Offsite Disposal	Contaminated material is removed and transported to permitted offsite treatment and/or disposal facilities.	Retained.
Treatment	In-situ Biological Treatment	Enhanced Bioremediation	Adding oxygen and nutrients aids indigenous or inoculated micro-organisms (e.g., fungi, bacteria, and other microbes) in degrading (metabolizing) organic contaminants found in soil and/or groundwater, converting them to innocuous end products.	Not retained. This technology is not suitable for metals or ACM and has limited effectiveness for PCBs.
	In-situ Biological Treatment	Phytoremediation	Using plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment.	Not retained. This technology is not suitable for metals or ACM and has limited effectiveness for PCBs.

Table 4–1. Initial Screening of Technologies (continued)

General Response Actions	Technology Type	Process Options	Description	Screening Results
	In-situ Physical/Chemical Treatment	Chemical Oxidation	Oxidation chemically converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. The oxidizing agents most commonly used are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide.	Not retained. This technology could pose practical operating difficulties given the shallow bedrock conditions encountered at FRBG, SRBG, and TRBG and the potential mobilization of contaminants into groundwater.
		Soil Flushing	Water, or water containing an additive to enhance contaminant solubility, is applied to soil or injected into groundwater to raise the water table into the contaminated soil zone. Contaminants are leached into the groundwater, which is then extracted and treated.	Not retained. Contaminants will be transferred into groundwater media that was evaluated in the Phase II RIs for all three sites.
		Solidification/ Stabilization	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).	Not retained. This technology has limited effectiveness for PCBs; although the technology reduces the mobility of PCBs, it does not destroy the PCBs.
	In-situ Thermal Treatment	Thermal Treatment	Steam/hot air injection or electrical resistance/electromagnetic/fiber optic/radio frequency heating is used to increase the volatilization rate of semi-volatiles and facilitate extraction.	Not retained. This technology has some limitations when contamination is very shallow and it could pose practical operating difficulties given the shallow bedrock conditions encountered at FRBG, SRBG, and TRBG.
	Ex-situ Biological Treatment	Biopiles	Excavated soil is mixed with soil amendments and placed in aboveground enclosures. It is an aerated static pile composting process in which compost is formed into piles and aerated with blowers or vacuum pumps.	Not retained. Technology focuses on remediating media contaminated with volatile petroleum hydrocarbons. Not suitable for ACM, metals, and PCBs, as volatility is limited.

Table 4–1. Initial Screening of Technologies (continued)

General Response Actions	Technology Type	Process Options	Description	Screening Results
	Ex-situ Biological Treatment	Landfarming	Contaminated soil, sediment, or sludge is excavated, applied into lined beds, and periodically turned over or tilled to aerate the waste.	Not retained. Technology focuses on remediating media contaminated with volatile petroleum hydrocarbons. Not suitable for ACM, metals, and PCBs, as volatility is limited. Also, there is a chance of contaminant movement to previously non-contaminated areas of the site.
	Ex-situ Physical/Chemical Treatment	Solvent Extraction	Waste-contaminated soil and extractant are mixed in an extractor, thereby dissolving the contaminants. The extracted solution is then placed in a separator, where the contaminants and extractant are separated for treatment and further use.	Not retained. Not suitable for ACM.
		Chemical Reduction/ Oxidation	Reduction/oxidation chemically converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert.	Not retained. Not suitable for ACM.
		Soil Washing	Contaminants sorbed onto fine soil particles are separated from bulk soil in an aqueous-based system on the basis of particle size. The wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organic chemicals and heavy metals.	Not retained. Not suitable for ACM.
		Solidification/ Stabilization	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).	Not retained. This technology has limited effectiveness for PCBs; although the technology reduces the mobility of PCBs, it does not destroy the PCBs.
	Ex-situ Thermal Treatment	Incineration	High temperatures, 870-1,200°C (1,600-2,200°F), are used to combust (in the presence of oxygen) organic constituents in hazardous waste.	Not retained. Not suitable for ACM.

Table 4-1. Initial Screening of Technologies (continued)

General Response Actions	Technology Type	Process Options	Description	Screening Results
	Ex-situ Thermal Treatment	Vitrification (Pyrolysis)	Chemical decomposition is induced in organic material by heat in the absence of oxygen. Organic material is transformed into gaseous components and a solid residue (coke) containing fixed carbon and ash.	Not retained. Not suitable for ACM.
		Thermal Desorption	Waste is heated in a mobile thermal treatment system to volatilize organic contaminants. The vapor emissions are treated using air filters, and the treated vapor is reused as an energy source for the operation of the thermal treatment system.	Not retained. Not suitable for ACM.

ACM = Asbestos-Containing Material
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
FRBG = Fox Road Burning Ground
LUC = Land use control
NCP = National Contingency Plan
PCB = Polychlorinated biphenyl
SRBG = Snake Road Burning Ground
TRBG = Taylor Road Burning Ground

Table 4–2. Detailed Screening of Technologies

General Response Actions	Technology Type	Process Options	Effectiveness	Implementability	Cost	Screening Comments
No Action	None	None	Not effective. Exposure to contaminants left in place goes unsupervised and uncontrolled.	Easy to implement. No activities are implemented.	No cost. No activities driving cost.	Retained. Required by CERCLA.
Removal	Bulk Removal	Excavation and Offsite Disposal	Effective. Once the contaminated soil is removed to achieve remedial CUGs, contaminant exposure to human health and the environment are eliminated allowing potential unrestricted reuse of the site.	Moderately easy to implement. Technology has been implemented successfully at NASA GRC-ATF in the past. Equipment for implementation is readily available and disposal facilities are available within a reasonable distance.	Moderate cost.	Retained.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CUG = Cleanup goal
GRC-ATF = Glenn Research Center at Neil A. Armstrong Test Facility
NASA = National Aeronautics and Space Administration

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5.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

This section describes the remedial alternatives developed and retained from the initial and detailed technology screening process. The retained remedial alternatives are composed of implementable and cost-effective technology types and process options that address COCs in soil at SRBG and TRBG, and detectable asbestos at all three sites.

The retained remedial alternatives are:

- Alternative 1: No Action; and
- Alternative 2: Excavation and Offsite Disposal – Attain Residential Land Use.

A detailed description of each remedial alternative is provided in the following sections.

5.1 ALTERNATIVE 1: NO ACTION

The no action alternative is required for evaluation under the NCP. This alternative is the baseline to which other remedial alternatives are compared. This alternative assumes all current actions (e.g., access restrictions and environmental monitoring) will be discontinued and no future actions will take place to protect human receptors or the environment. COCs at SRBG and TRBG, and asbestos at all three sites will not be removed or treated.

5.2 ALTERNATIVE 2: EXCAVATION AND OFFSITE DISPOSAL – ATTAIN RESIDENTIAL LAND USE

This alternative would include the excavation and offsite disposal of surface soil (0 to 2 ft bgs) at FRBG and SRBG, and surface and subsurface soil (0 to 2 ft bgs and 2 to 6 ft bgs) at TRBG containing COCs or asbestos at concentrations above the remedial CUGs to achieve residential land use conditions. Land use controls (LUCs) will not be required for any receptor at both sites upon completion of the excavation and disposal activities. The estimated extents of "hotspot" excavation at FRBG, SRBG, and TRBG are presented in Figures 2-1, 2-2, and 2-3, respectively. Implementation of Alternative 2 would result in excavation and offsite disposal of approximately 56 cubic yards of contaminated soil from FRBG, approximately 2,056 of contaminated soil from SRBG, and approximately 1,543 CY of contaminated soil from TRBG. The volumes of soil being removed from FRBG, SRBG, and TRBG are presented in Table 2-2, 2-3, and Table 2-4, respectively.

This remedial alternative will require coordinating remediation activities with Ohio EPA and NASA. Coordinating with stakeholders during implementation of the excavation will minimize health and safety risks to onsite personnel and potential disruption of NASA mission activities. The time period to complete this remedial action is relatively short and will not require long term management of the sites associated with LUCs because residential land use conditions will be achieved. Major components of this remedial alternative include:

- Remedial design (RD);
- Waste characterization;
- Pre-excavation delineation sampling;
- Excavation and offsite disposal of soil;
- Confirmation sampling; and
- Site restoration.

Remedial Design – An RD will be developed prior to initiating remedial actions. The RD will outline construction permitting requirements; site preparation activities (e.g., staging and equipment storage areas, truck routes, dust control, storm water controls); asbestos abatement plan (if necessary); the extent of the excavation; sequence and description of excavation and site restoration activities; decontamination of construction and sampling equipment; and segregation of waste materials, transportation, and waste disposal. Erosion, and health and safety controls will be enforced during the active construction period to ensure remediation workers and the environment are protected. As part of the RD, additional pre-excavation sampling will be conducted to better refine the targeted lateral and vertical extents for soil removal.

Waste Characterization Sampling – Waste characterization analysis would be completed to confirm the excavated material is non-hazardous. The soil removal areas would be sampled in place and analyzed for toxicity characteristic leaching procedure (TCLP) metals, TCLP semi-volatile organic compounds, TCLP volatile organic compounds, TCLP pesticides, TCLP herbicides, pH, explosives, asbestos, total cyanide, total sulfide, and PCBs to support waste profiling requirements for offsite disposal or as required by the receiving disposal facility. Waste characterization samples will be generally collected as a five-part composite sample at the frequency of 1 sample per every 300 CY of excavated material or focused on specific removal areas. If PCB remediation waste exceeds 1 part per million (ppm) then soil will be disposed as PCB-remediation waste per §761.61(b). The removal area at SRBG-SL-008 has a high concentration of silver (1,000 mg/kg). This concentration would indicate the material may be considered to be characteristically hazardous waste by the "Rule of 20." Accordingly, the removal area at SRBG-SL-008 will have its own waste characterization sample for verification.

This FS assumes that the soil is non-RCRA, ACM hazardous waste and does have asbestos requiring ACM-specific handling and disposal. To verify, the soil will be analyzed for asbestos content as part of waste characterization. During the 2015 SI, the asbestos content in soil at TRBG was 3.5% chrysotile at TRBG-SL-001 and 1.75% chrysotile at TRBG-SL-002. These samples were collected at the time the white cementitious material was sampled (and removed in its entirety). If the soil is found to have greater than 1% asbestos during the waste characterization and/or pre-excavation delineation sampling, the waste disposal and excavation activities will be to be reassessed and finalized in the RD.

Pre-Excavation Delineation Sampling – To refine extents of the remedial areas recommended for removal, soil removal areas would be sampled for COCs including PCBs, metals, explosives, and/or asbestos in soil. Pre-excavation delineation sampling that fully defines the excavation footprints prior to implementation of the remedial action may be used in lieu of confirmation samples. Actual numbers of pre-excavation delineation samples will depend on the size of each area recommended for removal.

Excavation and Offsite Disposal of Soil – Site preparation would include clearing any obstacles, surface structures, or vegetation that would interfere with excavation, identifying utilities, and setting up temporary decontamination facilities. In addition, sediment and erosion control measures, including silt fences, would be installed to control runoff from the work area. Soil removal will be accomplished using conventional construction equipment such as backhoes, bulldozers, front-end loaders, and scrapers. Dust-control will also be implemented, as necessary, during the excavation and loading activities. Oversized debris will be crushed or otherwise processed to meet disposal facility requirements.

Excavated soil will be direct loaded on trucks for hauling to a licensed and permitted disposal facility. All trucks will be inspected prior to exiting the sites. Appropriate waste manifests will accompany each waste shipment. Only regulated and licensed transporters and vehicles will be used. All trucks will travel pre-designated routes within the NASA GRC-ATF facility.

Excavated soil will be disposed at an existing offsite facility licensed and permitted to accept the characterized waste stream. The selection of an appropriate facility will consider the type of waste, location,

transportation options, and cost. Based on the RI sampling results, it is anticipated that the soil contaminated with low concentrations of PCBs, asbestos, and other constituents will be disposed at a facility such as the EnviroSafe Services of Ohio, Inc. (EnviroSafe) facility located approximately 60 miles from NASA GRC-ATF. The EnviroSafe facility is an approved chemical waste landfill under 40 CFR § 761.75, RCRA Subtitle C Treatment and Disposal Facility that accepts non-hazardous and RCRA hazardous wastes, including PCB wastes (less than 50 ppm) and asbestos.

To achieve green remediation, it is important to fully assess the planned environmental remediation with a view to identify and implement sustainable practices, or develop innovative approaches that would reduce the energy, water and materials used during the remedial effort. During implementation of the remedial action, low-sulfur (or ultra-low sulfur) fuel shall be utilized in all construction equipment and field vehicles lowering sulfur emissions (alternately biodiesel blend to lower greenhouse gases [GHG]. Demobilization of equipment from area to area will be minimized, saving decontamination water. An attempt will be made to obtain backfill and cover soil from a local source, minimizing fuel use and emissions by delivery trucks. Appendix B includes a detailed GSR evaluation.

Confirmation Sampling – Upon completing the excavations at FRBG, SRBG, and TRBG, visual inspections will be performed, and confirmatory soil samples will be collected from each floor and sidewall of the "hotspot" excavation areas by a licensed asbestos hazard evaluation specialist, to ensure contaminated soils have been successfully removed. NASA may elect to collect sufficient pre-excavation samples in lieu of the post-excavation confirmation sampling activity.

Confirmation samples will be generally collected from each excavation as follows: one sample along each sidewall and one sample from the excavation bottom. However, the actual number of confirmation samples will depend on field conditions during excavation. The confirmatory soil samples will be analyzed for asbestos or COCs associated with each respective excavation area and laboratory results will be compared to remedial CUGs. The confirmation soil sampling will determine whether the removal action was fully successful in attaining remedial CUGs. Depending on the initial confirmation results, additional excavation may be conducted, as needed, until CUGs are met. Once the laboratory analysis determines COC and asbestos concentrations upon final excavation are below remedial CUGs, the sites will meet requirements for residential land use conditions.

Restoration **–** Upon completing soil excavation, all disturbed and excavated areas will be backfilled with clean soil, compacted, and graded to match neighboring contours. The backfill soil will come from a clean source location approved by NASA. After the area is backfilled and graded, workers will apply a NASA-approved seed mixture and mulch. A remedial action completion report will be prepared to document in detail all activities completed under this alternative.

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6.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

6.1 INTRODUCTION

This section presents a detailed analysis of the viable remedial alternatives retained and developed throughout the technology screening process. The purpose of this detailed analysis is to select an appropriate remedy at FRBG, SRBG, and TRBG. CERCLA guidance suggests the principal element of the selected remedy should reduce volume, toxicity, or mobility. If the selected remedy's principal element does not meet this criterion, an explanation as to why must be presented. In addition, the remedy must meet the following four statutory requirements:

- Be protective of human health and the environment;
- Comply with ARARs (or provide justification for a waiver);
- Be cost effective; and
- Use permanent solutions and treatment or recovery technologies to the maximum extent practicable.

This FS uses the threshold criteria and balancing criteria defined in the NCP at 40 CFR § 300.430(e)(q)(iii) to perform a detailed analysis of remedial alternatives to ensure the selected alternative meets the above CERCLA statutory requirements. These criteria are described in the following subsections.

6.1.1 Threshold Criteria

There are two evaluation criteria classified as threshold criteria. This criteria group relates directly to statutory findings. Threshold criteria must be met by the selected remedy. The evaluation criteria in this group are:

1. Overall protection of human health and the environment; and
2. Compliance with ARARs.

Each alternative must be evaluated to determine how it achieves and maintains protection of human health and the environment. An alternative is considered to be protective of human health and the environment if it complies with medium-specific CUGs. Similarly, each remedial alternative must be assessed to determine how it complies with ARARs or, if a waiver is required, an explanation of why a waiver is justified must be presented.

6.1.2 Balancing Criteria

There are five evaluation criteria classified as balancing criteria. This group represents the primary criteria upon which the detailed and comparative analysis of each remedial alternative are based. The evaluation criteria in this group are:

1. Long-term effectiveness and permanence;
2. Reduction of toxicity, mobility, or volume through treatment;
3. Short-term effectiveness;
4. Implementability; and
5. Cost.

Long-term effectiveness and permanence evaluates the magnitude of residual risk (risk remaining after implementing the alternative) and the adequacy and reliability of controls used to manage the remaining waste (untreated waste and treatment residuals) over the long term. Alternatives that provide the highest degree of long-term effectiveness and permanence leave little or no untreated waste at the site, make long-term maintenance and monitoring unnecessary, and minimize the need for LUCs.

Reduction of toxicity, mobility, or volume through treatment evaluates the ability of the alternative to reduce the toxicity, mobility, or volume of the waste. The irreversibility of the treatment process and the type and quantity of residuals remaining after treatment are also assessed.

Short-term effectiveness addresses the protection of workers and the community during the remedial action, the environmental effects of implementing the action, and the time required to achieve media-specific preliminary CUGs.

Implementability addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during implementation. Technical feasibility assesses the ability to construct and operate a technology, the reliability of the technology, the ease in undertaking additional remedial actions, and the ability to monitor the effectiveness of the alternative. Administrative feasibility is addressed in terms of the ability to obtain approval from federal, state, and local agencies.

Cost analyses estimate the dollar cost of each alternative. The cost estimates in this report are based on reference manuals, historical costs, vendor quotes, and engineering estimates. Costs are reported in base year 2022 dollars and are not discounted. The cost estimates are for guidance in project evaluation and implementation and are believed to be accurate within a range of -30% to +50%, in accordance with USEPA guidance (USEPA 1988). Actual costs could be higher than estimated due to unexpected conditions or potential delays. Details and assumptions used in developing cost estimates for each of the alternatives are provided in Appendix C.

6.1.3 Modifying Criteria

The following two modifying criteria are briefly discussed in this FS. These criteria will be evaluated in consideration of regulatory comments received on this FS, and on public comments on the preferred remedial alternative presented in the Proposed Plan:

- State acceptance
- Community acceptance

6.1.4 Green and Sustainable Remediation (GSR) Evaluation

As part of the comparative analysis with respect to the nine CERCLA criteria, a GSR evaluation for Alternative 2 is also included (Appendix B). USEPA currently defines "green" remediation as "the practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions." USEPA guidance regarding green remediation is provided in the documents entitled Principles for Greener Cleanups (USEPA 2009), Methodology for Understanding and Reducing a Project's Environmental Footprint (USEPA 2012a), and Superfund Green Remediation Strategy (USEPA 2010).

USEPA's guidance states that green remediation must still meet threshold requirements for protectiveness and other site-specific cleanup objectives (i.e., the nine criteria discussed above). Thus, green remediation

is intended to decrease the environmental footprint of the cleanup action rather than trade cleanup objectives for other environmental objectives.

Long-term effectiveness and permanence. Also considered in this category are greenhouse gas (GHG) emissions and total energy consumed as a result of the long-term implementation of an alternative. GSR assessment details for Alternative 2 are included in Appendix B.

Short-term effectiveness. The following GSR metrics are also considered in this category: particulates less than 10 micrometers (PM10), oxides of sulfur (SOx) and oxides of nitrogen (NOx) emissions, total water used and consumed, and worker safety risks as a result of selecting the alternative. These have been included in the short-term criterion due to their immediate localized impacts.

6.2 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

A detailed analysis of each alternative against the seven NCP evaluation criteria is contained in the following sections. The detailed analysis further defines each alternative (if necessary), compares the alternatives against one another, and presents considerations common to the alternatives.

As presented in Section 5.0, the following remedial alternatives were retained:

- Alternative 1: No Action; and
- Alternative 2: Excavation and Offsite Disposal – Attain Residential Land Use.

6.2.1 Alternative 1: No Action

Under this alternative, no remedial actions will take place for soil contamination to meet the RAO. The contaminated soil requiring remediation will be left in place. Any existing access restrictions will not be continued. Environmental monitoring will not be performed, and no restrictions on land use will be implemented.

6.2.1.1 Overall Protection of Human Health and the Environment

The no action alternative would not provide any protection because no remedial actions would be implemented to prevent the potential exposure to soil COCs at SRBG and TRBG, or detectable asbestos at all three sites.

6.2.1.2 Compliance with ARARs

The no action alternative would not comply with the ARARs identified in Section 4.0 because no remedial action would be taken under this alternative.

6.2.1.3 Long-Term Effectiveness and Permanence

This alternative does not provide long-term effectiveness and permanence. Exposure risks would essentially remain unchanged as no remedial action would be taken and there is no concern about the adequacy and reliability of controls because none would be applied.

6.2.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

There would be no reduction in toxicity, mobility, or volume through treatment with the no action alternative.

6.2.1.5 Short-Term Effectiveness

There would be no additional risks posed to the community, workers, or the environment as a result of implementing this alternative.

6.2.1.6 Implementability

This alternative is readily implementable.

6.2.1.7 Cost

The present value cost to complete Alternative 1 is $0. No capital and O&M costs are associated with this alternative.

6.2.2 Alternative 2: Excavation and Offsite Disposal – Attain Residential Land Use

This alternative will achieve residential land use conditions by implementing excavation and offsite disposal of contaminated soils from FRBG, SRBG, and TRBG. The excavated soil will be transported to an offsite permitted disposal facility. Upon removing the contaminated soil and attainment of remedial CUGs, no LUCs will be required at either site.

6.2.2.1 Overall Protection of Human Health and the Environment

This alternative would provide adequate protection of human health and the environment through the removal of soil contaminated with COCs above remedial CUGs. Following implementation of this alternative, the human health risks associated with residential receptors would be eliminated. Removing contamination within these sites, as described in the remedial alternative, results in the sites being protective of human health for residential land use.

6.2.2.2 Compliance with ARARs

This alternative would comply with the ARARs presented in Section 4.0. Action-specific ARARs for this alternative deal primarily with characterizing, managing, and disposing contaminated soil generated from excavation. Disturbing the soil will also trigger ARARs for controlling fugitive dust emissions and potentially erosion control measures. Location-specific ARARs would also apply at SRBG due to the presence of wetland conditions and rare plant and T&E species, and location-specific ARARs would apply at TRBG due to the presence of ephemeral wetland conditions. The proposed remedial action under this alternative will comply with these action-specific and location-specific ARARs.

6.2.2.3 Long-term Effectiveness and Permanence

Alternative 2 would provide a high degree of long-term effectiveness and permanence. Contaminated soil exceeding remedial CUGs will be excavated at FRBG, SRBG and TRBG and transported to an offsite disposal facility to result in residential land use conditions at the sites, thereby mitigating risks to human health and the environment. Consequently, LUCs are not required after removal activities are complete. No CERCLA 5-year reviews or O&M sampling are required.

Alternative 2 would result in the generation of GHGs, primarily as a result of transportation of personnel, equipment, and excavated soil; and operation of heavy equipment during soil removal and loading trucks. A detailed GSR evaluation for this alternative is included in Appendix B.

6.2.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 would remove contaminated soil from the site, thereby reducing toxicity, mobility, and volume of contaminants at the site. However, in the absence of treatment, the toxicity and volume of excavated material will not be reduced at the offsite disposal facility. The mobility of contaminants will be reduced by placing the excavated material in an appropriately designed and permitted disposal facility.

6.2.2.5 Short-Term Effectiveness

There will be potential short-term worker and community exposures associated with Alternative 2. Workers may be exposed during excavation activities. A health and safety plan (including asbestos abatement plan, if applicable) that identifies appropriate PPE for workers will minimize and/or eliminate exposures. Mitigation measures during excavation, such as erosion and dust control, will minimize/eliminate potential short-term impacts.

The community near the site and along the route to the disposal facility may be exposed during soil transportation activities. The community will be protected during soil transport by conducting vehicle inspections before and after use, decontaminating as needed, covering the transported waste, observing safety protocols, following pre-designated routes, and limiting the distance to the disposal facility. Transportation risk associated with material leaks will increase with distance and volume of material. Transporting soil to an offsite disposal facility will comply with all applicable state and federal regulations. Pre-designated travel routes will be established, and an emergency response program will be developed to facilitate any potential accident response.

Completion of excavation activities and site restoration is estimated to be completed in less than 1 year. Upon completing the excavation activities, FRBG, SRBG, and TRBG will attain residential land use conditions for soil.

The following GSR metrics are also considered in this category: PM10, SOx and NOx emissions, total water used and consumed, and worker safety risks as a result of selecting the alternative. These have been included in the short-term criterion due to their immediate localized impacts.

This alternative would result in consumption of hazardous waste landfill space. Alternative 2 would include the creation of approximately 6,576 tons of hazardous landfill waste consisting of asbestos and COC-contaminated soil. A detailed GSR evaluation for this alternative is included in Appendix B.

6.2.2.6 Implementability

Alternative 2 will be easily implemented after the RD is developed and approved by stakeholders and all appropriate coordination with local, state, and federal agencies is completed. Excavating soil, constructing temporary roads, as necessary, and conducting waste handling are conventional, straightforward construction techniques and methods. Multiple offsite disposal facilities will be available to accept generated waste. Resources (e.g., equipment, material, trained personnel) to implement this alternative will be readily available.

Excavation activities will be coordinated with NASA to minimize impacts to NASA mission activities. The RD will identify access routes to the sites for heavy equipment and provide steps to minimize potential hazards to on-site personnel.

6.2.2.7 Cost

The present value cost to complete Alternative 2 is approximately $3,233,451 (in base year 2022 dollars). See Appendix C for a detailed description of Alternative 2 costs.

6.2.2.8 State Acceptance

This criterion evaluates remedial alternatives with respect to meeting the concerns of state regulatory agencies. Comments will be solicited from Ohio EPA during the public review period for the Proposed Plan (PP). These comments will be considered in the remedy-selection process. A summary of state comments and responses will be included in the responsiveness summary in the Record of Decision (ROD).

6.2.2.9 Community Acceptance

This criterion assesses issues of concern to the community for each remedial alternative. Comments will be solicited from community members during the public review period for the PP. In addition, a public meeting will be hosted to present the key components of the PP to the public in accordance with NASA's Community Involvement Plan for CERCLA Activities at Plum Brook Station (Leidos 2020). These comments will be considered in the remedy-selection process. A summary of public comments and responses will be included in the responsiveness summary in the ROD.

6.2.3 Comparative Analysis of Remedial Alternatives Using NCP Criteria

The comparative analysis provides a means by which remedial alternatives can be directly compared to one another with respect to common criteria. Table 6-1 provides a comparative analysis of the alternatives evaluated in this FS.

Overall protection and compliance with ARARs are threshold criteria that must be met by any alternative to be eligible for selection. If any alternative is considered "not protective" for overall protectiveness of human health and the environment or "not compliant" for compliance with ARARs, it is not eligible for selection as the recommended alternative.

Alternative 1 is not protective of human health and is not compliant with ARARs. In addition, Alternative 1 does not meet the RAO. Therefore, Alternative 1 is not eligible for selection.

Alternative 2 provides adequate long-term protection of human health and the environment. Alternative 2 also provides a high degree of long-term effectiveness and permanence because the contaminated soil/sediment would be excavated and disposed offsite to attain COC concentrations below remedial CUGs and asbestos not detected. While Alternative 2 does not involve treatment, it involves excavation and offsite disposal of contaminated soil, thereby reducing the toxicity, mobility, and volume of contamination remaining at the site. Excavation and offsite disposal pose a modest risk to the community due to the transportation of contaminated soil on public roads. Proper soil handling techniques would be implemented to prevent or minimize adverse environmental impacts during the implementation of this alternative. Risks to site workers during soil excavation and loading would be mitigated through appropriate health and safety practices addressed in the health and safety plan (and asbestos abatement plan, if applicable). Alternative 2 is readily implementable since soil excavation is a commonly used remedial technology to address contaminated soil. Services and materials required for this alternative are readily available and offsite disposal facilities will be easily available to accept generated waste. Alternative 2 will implement GSR best management practices to reduce the environmental footprint (Appendix B).

Table 6–1. Comparative Analysis of Remedial Alternatives

Remedial Action Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction in Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Total Present Value Cost[a]
Alternative 1: No Action	○	○	○	○	◒	●	$0
Alternative 2: Excavation and Offsite Disposal - Attain Residential Land Use	●	●	●	●	●	●	$3,233,451

[a] A discounted rate is not applicable to Alternative 2. All costs for Alternative 2 are in base year 2022 dollars.
ARAR = Applicable or relevant and appropriate requirement

● = Fully meets criterion

◒ = Partially meets criterion

○ = Does not meet criterion

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7.0 CONCLUSIONS AND RECOMMENDED ALTERNATIVE

The RI Reports for FRBG, SRBG, and TRBG concluded that the nature and extent of contamination at each site was adequately defined in accordance with CERCLA requirements. Soil requiring remediation at FRBG, SRBG, and TRBG was identified. In addition, all three sites had surface debris that NASA can consider removing as part of the remedial action. The RI Reports provide some detail about this debris; however, it is worth noting that this debris (i.e., metal scrap, cinder blocks) does not pose an additional chemical risk to human health or the environment.

The purpose of this FS is to evaluate contaminated soil media at FRBG, SRBG, and TRBG that pose a potential risk to human health and the environment and identify RAOs and appropriate CUGs, screen remedial technologies, develop remedial alternatives to meet the RAOs and attain CUGs, and perform a detailed evaluation of remedial alternatives to identify a recommended alternative. The extent of soil contamination posing a risk to hypothetical residential receptors was limited to surface soil (0 to 2 ft bgs) at FRBG and SRBG, and limited to surface soil (0 to 2 ft bgs) and shallow subsurface soil (2 to 6 ft bgs) at TRBG. The extent of soil contamination posing a risk to ecological receptors was limited to surface soil (0 to 2 ft bgs) at SRBG. Consequently, remedial alternatives were developed and evaluated to determine the most feasible alternative for FRBG, SRBG, and TRBG.

Remedial alternatives were developed for individual and comparative evaluation using the threshold and balancing criteria established by USEPA to address CERCLA criteria and statutory considerations. A detailed analysis of the alternatives was conducted against the "threshold" and "balancing" criteria, and alternative GSR criteria, followed by a comparative analysis, to determine the advantages or disadvantages of each alternative with respect to each other. Two remedial alternatives were developed and evaluated to address soil contamination at FRBG, SRBG, and TRBG:

- Alternative 1: No Action; and
- Alternative 2: Excavation and Offsite Disposal – Attain Residential Land Use.

While Alternative 1 is not protective or compliant with all the NCP threshold criteria, Alternative 2 is fully compliant with the NCP criteria and is the recommended alternative for FRBG, SRBG, and TRBG. Under this recommended alternative, all contaminated soil with COC or detectable asbestos concentrations exceeding remedial CUGs will be excavated and disposed offsite. Implementation of Alternative 2 would result in excavation and offsite disposal of approximately 56 CY of contaminated soil from FRBG, approximately 2,056 CY of contaminated soil from SRBG, and approximately 1,543 CY of contaminated soil from TRBG. The excavation will be backfilled with clean native fill material from a NASA-approved source and seeded with grass cover to restore the excavated area to the surrounding site conditions. There will be no O&M activities or 5-year CERCLA reviews necessary under this alternative because the remedial action will attain CUGs protective of residential land use conditions. The total present value cost for recommended Alternative 2 at FRBG, SRBG, and TRBG is estimated to be $3,233,451.

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APPENDIX A

SUPPLEMENTAL RISK EVALUATION

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Appendix A
Supplemental Risk Evaluation

Human health and ecological evaluations were conducted to determine if methods and/or soil screening values have changed since the soils Remedial Investigations (RIs) were conducted in 2018 (Leidos 2018) and revised in 2022 to address the presence of asbestos (Leidos 2022). If methods and/or screening values changed, the impact of the changes to the risk assessment conclusions also was evaluated.

Human Health Evaluation

An analysis was conducted to evaluate the impact of U.S. Environmental Protection Agency (USEPA) regional screening levels (RSL) changes to the human health soil chemical of concern (COC) selection and human health risk assessment (HHRA) conclusions in the Fox Road, Snake Road, and Taylor Road Burning Grounds soils RIs. The RIs were conducted in 2018 and some RSLs have changed since that time. The analysis was conducted following the steps listed below:

1. All detected analytes were compared to the May 2022 RSLs (USEPA 2022) and entries with exceedances were flagged.
2. For the chemicals with flagged exceedances, the November 2017 RSLs (USEPA 2017) were compared to the May 2022 RSLs and a subset of chemicals were flagged where the May 2022 RSLs were less than the November 2017 RSLs.
3. After this step, 3 chemicals were identified (2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, and cadmium) with detections in specific locations (i.e., listed in Table 1) for risk analysis.
4. The hazard quotients (HQs) associated with the detected concentrations were calculated (the RSL for all 3 chemicals is based on noncancer effects).
5. The calculated HQs, along with the existing chemical of potential concern (COPC) HQs and total HIs, were examined to determine if the new chemicals would cause unacceptable risk and be selected as COCs.
6. The rationale for the selection is explained in Table 1.

In accordance with USEPA risk assessment guidance, if the total noncancer hazard index (HI) exceeds the target of 1, the HQs are segregated according to the target organ/system that the chemical affects, re-summed, and the total target organ/system HI is compared to the target of 1. In the case of cadmium, the target organ/system HI was calculated because some of the non-segregated HIs exceed 1. As discussed in Table 1, no additional COCs were identified at any of the burning grounds because the total HI or total target organ/system HI did not exceed 1.

Ecological Evaluation

An analysis was conducted to evaluate the impact of Ohio Environmental Protection Agency (Ohio EPA) ecological risk assessment guidance changes to the chemicals of potential ecological concern (COPECs) selection and ecological risk assessment (ERA) conclusions in the Fox Road, Snake Road, and Taylor Road Burning Grounds soils RIs. The 2008 and 2018 versions of the *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2008, 2018) were compared for substantive changes that could affect the conclusions of the previous Burning Ground soils RIs which were completed using the 2008 guidance.

A number of the changes in the 2018 guidance related to the evaluation of surface water and sediment in aquatic systems which are not relevant to the three burning grounds. The following minor changes were noted that were applicable to the evaluation of soils:

- There is an option in the 2018 guidance to use alternate concentration estimates (e.g., 95 Percent Upper Confidence Limit [95UCL]) with prior approval from Ohio EPA for the screening comparison provided hotspots or outliers indicative of contamination are not present. In the 2008 guidance, that option was not available and the comparison was against the maximum detected concentration (MDC). The 95UCL can also be used for the background comparison in the 2018 guidance, but again was not available for comparison in the 2008 guidance. Use of the 95UCL would not have affected the no further action (NFA) conclusions of the Fox Road and Taylor Road screening level ecological risk assessment (SLERAs) because they were already based on using the more conservative MDC. Use of the 95UCL instead of the MDC also would not have affected any decisions identifying preliminary or final COPECs at Snake Road Burning Ground.

- For the Level II COPEC screen, the 2018 guidance specifies that for screening sources with multiple receptors (e.g., the USEPA ecoSSLs), the lowest screening value should not automatically be selected and the soil screening values selected should be justified (e.g., based on the most likely receptors to be exposed at the site, values with most confidence in derivation). In keeping with the conservative nature of a SLERA, the lowest screening value was always selected in the previous Burning Grounds RIs. In many cases the most conservative screening values are for avians or mammals but it is reasonable to conclude these receptors would be exposed at each of the burning grounds. In addition, in some cases the lowest ecoSSLs were below background but the weight-of-evidence evaluation factored this into account. Thus, this change would not have changed any of the previous results.

- There are additional PBT chemicals listed in the 2018 guidance that were not in the 2008 guidance but none of these chemicals were detected at any of the three Burning Grounds.

The only potential substantive change involved Ohio EPA eliminating the USEPA Region 5 *Ecological Screening Levels* (ESLs) as the third source of soil screening values from their selection hierarchy. However, Ohio EPA does not recommend a source replacement for the USEPA Region 5 ESLs in their screening hierarchy. Given the conservative nature of the USEPA Region 5 ESLs, they were retained in the ERAs. As a result, there were no changes to the SLERAs.

In summary, after examining the soil screening hierarchy and other smaller changes between the 2008 and 2018 guidance, there are no new preliminary or final COPECs identified at any of the burning grounds. The risk assessment conclusions remain the same. No Further Action for ecological receptors remains the recommendation for Fox Road Burning Ground and Taylor Road Burning Ground. The final COPECs identified for further evaluation in a feasibility study (FS) at the Primary Burn Area exposure unit at Snake Road Burning Ground remain cadmium, lead, mercury, PCB-1260, and 2,6- dinitrotoluene (DNT).

References

Leidos 2018. *Remedial Investigation Report for Fox Road, Snake Road, and Taylor Road Burning Grounds, National Aeronautics and Space Administration, Glenn Research Center – Plum Brook Station, Sandusky, Ohio.* April 2018.

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Ohio EPA (Ohio Environmental Protection Agency) 2008. *Guidance for Conducting Ecological Risk Assessments (DERR-00-RR-31).* Division of Emergency and Remedial Response. Revised April 2008.

Ohio EPA (Ohio Environmental Protection Agency) 2018. *Guidance for Conducting Ecological Risk Assessments.* Division of Environmental Response and Revitalization. Revised July 2018.

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APPENDIX B

GREEN AND SUSTAINABLE REMEDIATION EVALUATION

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APPENDIX B

GREEN AND SUSTAINABLE REMEDIATION EVALUATION

Leidos has prepared this green and sustainable remediation (GSR) evaluation appendix to the Feasibility Study (FS) for the National Aeronautics and Space Administration John H. Glenn Research Center at Neil A. Armstrong Test Facility (GRC-ATF) Burning Grounds, which evaluates the green and sustainable remediation (GSR) metrics for remedial alternatives considered for mitigating environmental impacts. This appendix assesses alternatives considered for Fox Road Burning Ground, Snake Road Burning Ground, and Taylor Road Burning Ground.

Two remedial alternatives were considered for the sites. These include:

- Alternative 1: No Action
- Alternative 2: Excavation and Offsite Disposal – Attain Residential Land Use.

In addition to the comparative analysis of remedial alternatives considered in the FS, an evaluation of the GSR of Alternatives 1 and 2 is included. The United States Environmental Protection Agency (USEPA) currently defines green remediation as "the practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions." USEPA guidance regarding green remediation is provided in *Principles for Greener Cleanups* (USEPA 2009) and *Methodology for Understanding and Reducing a Project's Environmental Footprint* (USEPA 2012).

USEPA's guidance states that green remediation must meet threshold requirements for protectiveness and other site-specific cleanup objectives (i.e., the nine criteria discussed in the FS [USEPA, 1988]). Thus, green remediation is intended to decrease the environmental footprint of the cleanup action rather than trade cleanup objectives for other environmental objectives.

For the purposes of this evaluation, use of standard equipment was assumed with conventional fuels (diesel or gasoline), with no particulate filters fitted to diesel-powered machinery. Local travel to and from the site was assumed for each of each phase of work (approximately 50 miles round trip).

The following five green remediation elements are listed in the USEPA's guidance documents and are relevant to selection of a GSR alternative for the site:

- Minimize total energy use and maximize renewable energy use;
- Minimize air pollutants and greenhouse gases (GHG) emissions;
- Minimize water use and impacts to water resources;
- Reduce, reuse, and recycle materials and waste; and
- Minimize land use and protect ecosystems.

B.1 Remedial Alternatives Assessment

This section describes the key components of the remedial alternatives and site-specific assumptions and parameters used for GSR evaluation. Assumptions for each alternative are described in the body of the FS.

B.1.1 Alternative 1 – No Action

Alternative 1 will leave the chemicals of concern (COCs), polychlorinated biphenyls (PCBs), silver, cadmium, lead, mercury, 2,6-Dinitrotoluene, and detectable asbestos, at the Burning Grounds in their existing state, with no further removal measures or institutional controls (ICs) to prevent unacceptable

exposure to COCs and asbestos. No active remediation, inspections, reviews, or groundwater monitoring will be performed under this alternative.

The No Action alternative provides a baseline against which other remedial alternatives are compared. This alternative will not include any activities to achieve the remedial action objectives (RAOs). If implemented, this alternative will be considered a final remedy for the sites listed above. No monitoring or periodic reviews will be conducted to verify the protectiveness of the No Action alternative.

B.1.1.1 Alternative 1 Greenhouse Gas Emissions

The No Action alternative will not generate GHG emissions.

B1.1.2 Alternative 1 Additional GSR Metrics

The No Action alternative will not require the use of energy or water; will not result in the generation of oxides of nitrogen (NOx), oxides of sulfur (SOx), or particulates less than 10 micrometers (PM10); and will not cause increased risks to workers during implementation.

B.1.2 Alternative 2 – Excavation and Offsite Disposal

Alternative 2 includes the following components that are relevant to the overall sustainability footprint:

- Transportation of personnel to and from the site
- Transportation of materials and equipment by truck (excavator, skid steer)
- Transportation of excavated soil and backfill materials

To achieve green remediation, it is important to fully assess the planned environmental remediation with a view to identify and implement sustainable practices, or develop innovative approaches that would reduce the energy, water and materials used during the remedial effort. During implementation of the remedial action, low-sulfur (or biodiesel blend) fuel shall be utilized in all construction equipment and field vehicles lowering sulfur and GHG emissions. The remedial contractor will minimize equipment engine idling and select construction equipment (properly sized) and energy sources to minimize fuel/energy use and emissions. Demobilization of equipment from area to area will be minimized, saving decontamination water. An attempt will be made to obtain backfill and cover soil from a local source within 20 miles of the site, minimizing fuel use and emissions by delivery trucks. Any construction debris will be recycled/reused to the maximum extent possible to also divert from landfill.

B1.2.1 Alternative 2 Greenhouse Gas Emissions

This alternative will generate GHGs, primarily as a result of transportation of personnel, equipment, and excavated soil.

B1.2.2 Alternative 2 Additional GSR Metrics

This alternative will require the use of energy to fuel vehicles to transport personnel, equipment, and soil, and to fuel the construction equipment and haul trucks. Alternative 2 will result in the generation of NOx, SOx, or PM10; and will cause increased risks to workers during implementation. There will decontamination water generated, primarily for pressure washing haul trucks and excavating equipment (alternately a certified truck wash may be used to limit onsite water use). Up to three 55-gallon drums are estimated to be generated. Approximately 5,177 tons of hazardous landfill waste consisting of asbestos-containing material and COC-contaminated soil will be generated during this alternative.

B1.3 Comparative Analysis of Alternatives

A comparative evaluation of sustainability assessment results for remedial alternatives is presented in this section. Alternative 1 will have no overall footprint, whereas Alternative 2 will, due to travel and equipment use.

B1.3.1 Comparative Analysis of Alternatives for Greenhouse Gas Emissions

Alternative 1 will not result in GHGs, whereas Alternative 2 will, primarily due to transportation of personnel, use of equipment, and hauling soil to the landfill.

B1.3.2 Comparative Analysis of Alternatives for Additional GSR Metrics

A comparison of GSR parameters is presented below:

- **Total energy used.** Alternative 1 will not require any energy use, whereas Alternative 2 will.
- **Water impacts.** Alternative 1 will not require the use of water, whereas Alternative 2 will, for pressure washing activities and dust suppression.
- **Nitrogen oxide emissions.** Alternative 1 will not result in NOx emissions, whereas Alternative 2 will, primarily due to a need for transportation and equipment use.
- **Sulfur oxide emissions.** Alternative 1 will not result in SOx emissions, whereas Alternative 2 will, primarily due to a need for transportation and equipment use.
- **Particulate emissions.** Alternative 1 will not generate PM10 emissions, whereas Alternative 2 will, primarily due to a need for transportation and equipment use and soil disturbance.
- **Accident risk – fatality.** Alternative 1 will not result in increased risk to site workers, whereas Alternative 2 will, primarily due to the number of onsite labor hours during construction-type activities, operation of construction equipment on the site, and transportation of personnel and materials over public roadways.
- **Accident risk – injury.** Alternative 1 will not result in increased risk to site workers, whereas Alternative 2 will, primarily due to transportation of personnel and soil, the number of onsite labor hours during construction-type activities, operation of construction equipment on the site, and transportation of personnel and materials over public roadways.

The greatest overall impacts for Alternative 2 are related to transportation of personnel, soil, and equipment, operation of construction equipment on site, and impacts from the manufacturing of the consumables required (primarily for GHG and energy use).

Additional sustainability metrics considered include nonhazardous and hazardous waste landfill space used. Comparison of these alternatives, with respect to these additional sustainability metrics, is discussed below:

- **Non-hazardous waste landfill space used**. Alternatives 1 and 2 will not consume non-hazardous landfill space
- **Hazardous waste landfill space used**. Alternative 1 will not consume hazardous landfill space, whereas Alternative 2 will (pending waste characterization results supporting the remedial design. (FS assumes asbestos will require hazardous waste disposal).

B.2 References

United States Environmental Protection Agency (USEPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. OSWER Directive 9355.1.*

United States Environmental Protection Agency (USEPA). 2009. *Principles for Greener Cleanups.* U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. August 27.

United States Environmental Protection Agency (USEPA). 2012. *Methodology for Understanding and Reducing a Project's Environmental Footprint.* U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Superfund Remediation Technology Innovation. February.

EPA/540/G-89/004. Office of Emergency and Remedial Response. Interim Final. October.

APPENDIX C

DETAILED COST ESTIMATE

(*Revised January 2023*)

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NASA Glenn Research Center at Neil A. Armstrong Test Facility
Feasibility Study - Soil at NASA GRC-ATF Burning Grounds
Alternative 2: Excavation and Off-Site Disposal - Attain Residential Land Use
Parameters and Assumptions

Item	Unit	Value	Notes
Capital Cost			
Pre-design Investigation			
Mobilization/Demobilization	$/ea	1,500	Includes soil sampling equipment rental, pickup truck and fuel
Pre-design Investigation workplan	hr	375	Includes HASP
Pre-design Investigation workplan	$/hr	85	
FRBG Delineation	ea	3	Remedial extent delineation for asbestos. Collect one soil sample from each proposed boring around FRBG-SL-024 (3 samples total). Sample interval: 0-2 ft bgs
Asbestos	ea	3	
SRBG Delineation	ea	17	Remedial extent delineation for asbestos, PCBs, cadmium, lead, mercury, silver, and 2,6-DNT. Collect one soil sample from each proposed boring around SRBG-SL-001, -DD-001, -SL-002, -SL-003, -SL-004, -SL-009, and -DD-002 (17 samples total). Sample interval: 0-2 ft bgs
Asbestos	ea	15	Soil samples from SRBG-SL-001, -DD-001, -SL-002, -SL-003, -SL-004, and -DD-002 locations
PCBs	ea	17	Soil samples from all boring locations
Cadmium, Lead, Mercury, and 2,6-DNT	ea	10	Soil sample from SRBG-SL-003 and -SL-004 locations
Silver	ea	2	Soil sample from SRBG-SL-009 location
TRBG Delineation	ea	32	Remedial extent delineation for asbestos and PCBs . Collect three soil samples from proposed borings at TR-6, TRBG-Sl-002, and TRBG-SDSW-004 locations (0-2 ft, 2-4 ft, and 4-6 ft bgs). Collect one soil sample from proposed borings at TRBG-SL-001 (0-2 ft bgs)
PCBs	ea	32	
Asbestos	ea	32	
Waste Characterization	ea	10	- Assume 5-part composite sample taken from the excavated soil at a frequency of one sample per every 500 CY/site (total 10 samples).
Waste characterization samples	$/ea	1,045	Sample analysis (historical cost) to include TCLP Metals, TCLP VOCs, TCLP SVOCs, TCLP Pesticides, TCLP Herbicides, explosives, Total Cyanide, Total Sulfide, pH, PCBs, and PFAS. Based on Laboratory MSA pricing for COMETS.
Sampling labor	day	6	Assumes 2 technicians and 6 days to collect samples @ 10 hrs/day
Sampling labor	$/day	1,400	Assumes $700/day per technician ($1400/day total)
Analytical Cost			
Asbestos	$/ea	150	historical cost
PCBs	$/ea	50	historical cost
Cadmium, Lead, Mercury, and 2,6-DNT	$/ea	235	historical cost
Silver	$/ea	25	historical cost
Pre-design Investigation Report	hr	150	
Pre-design Investigation Report	$/hr	85	

NASA Glenn Research Center at Neil A. Armstrong Test Facility
Feasibility Study - Soil at NASA GRC-ATF Burning Grounds
Alternative 2: Excavation and Off-Site Disposal - Attain Residential Land Use
Parameters and Assumptions

Item	Unit	Value	Notes
Wetland Delineation			
Field Activities	day	3	Historical cost. Assumes 2 scientists @ 10 hrs/day
Field Activities	$/day	2,200	Assumes $1100/day per scientist ($2200/day total)
Delineation Report	hr	80	
Delineation Report	$/hr	85	
Site Work			
Civil Survey	ea	2	Survey of the site boundaries and excavated extents (pre- and post excavation
Civil Survey	$/day	5,000	Survey and report (historical cost)
Remedial Design	ea	1	workplan (includes drawings and HASP) and procurement activities
Remedial Design	hours	550	workplan (includes drawings and HASP) and procurement activities. Includes draft and final. Includes HASP for prime and subcontractor.
Technical Labor	$/hr	85	
Site preparation - clearing	$/LS	2,500	RSMeans #311313200300. Equipment mobilization/demobilization, includes 300HP dozer and rotary mower
FRBG Site preparation	$/acre	1,500	RSMeans #311313200300. Trees/brush cleared, chipped and left onsite
SRBG Site preparation	$/acre	750	RSMeans #311313101080. Brush hogging, no tree removal
TRBG Site preparation	$/acre	1,500	RSMeans #311313200300. Trees/brush cleared, chipped and left onsite
Sediment and erosion controls	LF	2,200	Includes silt fence and compost/mulch sock to protect drainage ditches and low lying areas downslope of the excavations
Sediment and erosion controls	$/LF	8	RSMeans #312514161000 & 312514160710
Soil Excavation			
Mobilization/Demobilization	ea	7,500	Includes equipment mobilization and demobilization
Soil Excavation Surface Area			
FRBG Soil Excavation	SF	625	One 25' x 25' excavation area
SRBG Soil Excavation	SF	23,125	Three 75' x 75' and one 50' x 125' excavation areas
TRBG Soil Excavation	SF	10,850	One 50' x 50', one 125' x50', and one 70' x 30' excavation areas
Soil Excavation Volume			
FRBG Soil Excavation	CY	56	
SRBG Soil Excavation	CY	2,056	
TRBG Soil Excavation	CY	1,543	Includes additional 20% volume at TRBG-SL-002 for excavation slope
Soil Excavation Weight			
FRBG Soil Excavation	ton	100	
SRBG Soil Excavation	ton	3,700	
TRBG Soil Excavation	ton	2,776	

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Alternative 2: Excavation and Off-Site Disposal - Attain Residential Land Use
Parameters and Assumptions

Item	Unit	Value	Notes
Excavate Soils	CY/day	240	Assume 240 cy soil removed/day
FRBG Soil Excavation	day	1	
SRBG Soil Excavation	day	9	
TRBG Soil Excavation	day	7	
Excavate Soils	$/day	9,000	Historical cost. Includes four OSHA Trained Personnel, Hydraulic Excavator, Front End Wheel Loader, Truck, Heavy Equipment Fuel, Misc. Hand Tools, Utility Vehicle . Assume trucks are direct loaded
Standby Time	day	5	Assume equipment standby while analysis is being performed. Assume no additional hotspot excavation
Standby Time	$/day	1,000	
Confirmation Sampling			
Confirmation Samples - FRBG	ea	5	- Assume discrete confirmation samples collected at the excavation as follows: Four sidewall and one floor samples
Sample Analysis - FRBG (asbestos)	$/ea	240	Sample analysis (historical cost) for asbestos. Includes 3-days expedited analysis (+60%)
Confirmation Samples - SRBG	ea	23	- Assume discrete confirmation samples collected at each excavation as follows: Minimum of four sidewall and one floor sample - Four excavations at SRBG (23 samples) - All samples analyzed for PCBs; Five samples analyzed for silver; 18 samples analyzed for asbestos; 13 samples analyzed for metals (cadmium, lead, and mercury), and explosives (2,6-DNT)
Sample Analysis - SRBG (PCBs)	$/ea	80	Sample analysis (historical cost) to include PCBs at the four SRBG excavations. Includes 3-days expedited analysis (+60%)
Sample Analysis - SRBG (silver)	$/ea	40	Sample analysis (historical cost) to include silver at one SRBG excavation. Includes 3-days expedited analysis (+60%)
Sample Analysis - SRBG (Asbestos)	$/ea	240	Sample analysis (historical cost) to include asbestos at three SRBG excavations
Sample Analysis - SRBG (cadmium, lead, mercury, and 2,6-DNT)	$/ea	375	Sample analysis (historical cost) to include metals (cadmium, lead, and mercury) and explosives (2,6-DNT) at two SRBG excavations. Includes 3-days expedited analysis (+60%)
Confirmation Samples - TRBG	ea	18	- Assume discrete confirmation samples collected at each excavation as follows: Minimum of four sidewall and one floor samples - Three excavations at TRBG (18 samples) - All samples analyzed for PCBs and asbestos
Sample Analysis - TRBG (PCBs)	$/ea	80	Sample analysis (historical cost) to include PCBs at the three TRBG excavation. Includes 3-days expedited analysis (+60%)
Sample Analysis -TRBG (Asbestos)	$/ea	240	Sample analysis (historical cost) to include asbestos at the three TRBG excavations. Includes 3-days expedited analysis (+60%)
Sampling labor	$/hr	70	
Sampling labor	hr	20	Assume 1 technician to collect and ship samples

NASA Glenn Research Center at Neil A. Armstrong Test Facility
Feasibility Study - Soil at NASA GRC-ATF Burning Grounds
Alternative 2: Excavation and Off-Site Disposal - Attain Residential Land Use
Parameters and Assumptions

Item	Unit	Value	Notes
Waste Disposal			
Waste Transportation & Disposal	$/ton	264	Based on quotes for hazardous waste, includes transportation and disposal costs to Envirosafe Services of Ohio facility (RCRA Subtitle C Landfill) (~ 60 miles away).
FRBG Soil Excavation	ton	100	soil to be transported and disposed off-site
SRBG Soil Excavation	ton	3,700	soil to be transported and disposed off-site
TRBG Soil Excavation	ton	2,776	soil to be transported and disposed off-site
Delineation Sampling Soil Waste - Transportation & Disposal	$/drum	692	Assume hazardous waste; 1 drum per BG site Pre-Remedial Design Investigation. Based on historical quote; ($692 minimum) $600 mob fee plus 35% fuel surcharge ($210), 10% EIR Fee
Decontamination Water Characterization	$/ea	967	Assume decontamination water from Pre-Remedial Design Investigation equipment decontamination, final excavator decontamination, excavation water, and initial truck bed. Assume five 55-gal drums (5 samples). Sample analysis: TCLP VOC, TCLP SVOCs, TCLP Pesticides, TCLP Herbicides, TCLP Metals, PFAS, PCBs, Total Sulfide, Total Cyanide, pH
Decontamination Water Management	gallon	275	Assume a total of five 55-gal drums
Decontamination Water Transportation & Disposal	$/gal	2.50	Based on historical quote. Assume characterization data will be acceptable for disposal and non-hazardous
Site Restoration			
Backfill	$/ton	22	Historical quote, material only
Hydric soil (topsoil)	$/ton	36	Historical quote, material only
Excavation Backfilling and Soil Compaction	$/CY	10	RSMeans #312323131300 and #312323131700. Dozer backfilling and compaction. 6" to 12" lifts, sheepsfoot roller
FRBG Common fill	ton	75	Assume common fill is 1.5 ft thick
FRBG topsoil	ton	25	Assume the top 6 inch would be topsoil for seeding
SRBG Common fill	ton	1,887	Assume 68% of excavation is outside the wetlands boundaries. Common fill is 1.5ft thick
SRBG Hydric soil (topsoil)	ton	1,813	Assume 32% of excavation is within the wetlands. Additional topsoil included for areas with common fill
TRBG Common fill	ton	672	Assume 28% of excavation is outside the wetlands boundaries, excludes upper 6" for topsoil
TRBG Hydric soil (topsoil)	ton	2,105	Assume 72% of excavation is within the wetlands. Additional topsoil included for areas with common fill
Topsoil Placement and Seeding	$/SY	12	RSMeans #329119131000 and 329219131100. 6" deep, fine grading and seeding
FRBG Topsoil Placement and Seeding	SY	69	
SRBG Topsoil Placement and Seeding	SY	2,569	
TRBG Topsoil Placement and Seeding	SY	1,206	
Backfill Sampling	$/ea	540	Assume 1 composite sample of each backfill and top soil source (NASA GRC Specification 31 23 01 98). Based on Laboratory MSA pricing for COMETS
SWPPP Inspection	hr	10	
SWPPP Inspection	$/hr	70	
Reporting			
Removal Action Completion Report	hr	300	Includes construction QC data and report preparation (draft and final)
Technical Labor	$/hr	85	
Operation & Maintenance Cost			
none			

NASA Glenn Research Center at Neil A. Armstrong Test Facility
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Alternative 2: Excavation and Off-Site Disposal - Attain Residential Land Use
Budgetary Cost Estimate

Capital Cost **$3,233,451**

Activity	Quantity	Unit	Unit Cost	Total
Capital Cost				
Pre-design Investigation				
Mobilization/Demobilization	1	ea	$1,500	$1,500
FRBG Delineation				
Asbestos	3	ea	$150.00	$450
SRBG Delineation				
Asbestos	15	ea	$150.00	$2,250
PCBs	17	ea	$50.00	$850
Cadmium, Lead, Mercury, and 2,6-DNT	10	ea	$235.00	$2,350
Silver	2	ea	$25.00	$50
TRBG Delineation				
Asbestos	32	ea	$150.00	$4,800
PCBs	32	ea	$50	$1,600
Waste Characterization				
Waste Characterization Samples	10	ea	$1,045	$10,450
Sampling Labor	6	Day	$1,400	$8,400
Pre-design Investigation Report	150	hr	$85	$12,750
Wetlands Delineation				
Field Activities	3	Day	$2,200	$6,600
Delineation Report	80	hr	$85	$6,800
Site Work				
Civil Survey	2	Day	$5,000	$10,000
Remedial Design	1	ea	$46,750	$46,750
Site Clearing - Mobilization/Demobilization	1	ea	$2,500	$2,500
Site Clearing - FRBG	1	Acre	$1,500	$1,500
Site Clearing - SRBG	1	Acre	$750	$750
Site Clearing -TRBG	1	Acre	$1,500	$1,500
Sediment and Erosion Controls	2,200	LF	$8	$17,600
Soil Excavation				
Mobilization	1	ea	$7,500	$7,500
Excavate Soil				
FRBG Excavation	1	Day	$9,000	$9,000
SRBG Excavation	9	Day	$9,000	$81,000
TRBG Excavation	7	Day	$9,000	$63,000
Standby Time	5	Day	$1,000	$5,000
Confirmation Sampling				
Sampling Labor	20	hr	$70	$1,400
Soil Confirmation Samples (FRBG)				
Asbestos	5	ea	$240	$1,200
Soil Confirmation Samples (SRBG)				
PCBs	23	ea	$80	$1,840
Silver	5	ea	$40	$200
Asbestos	18	ea	$240	$4,320
Metals (cadmium, lead, and mercury) and Explosives (2,6-DNT)	13	ea	$375	$4,875
Soil Confirmation Samples (TRBG)				
PCBs	18	ea	$80	$1,440
Asbestos	18	ea	$240	$4,320
Waste Disposal				
Hazardous Waste Disposal				
FRBG Soil Excavation	100	ton	$264	$26,400
SRBG Soil Excavation	3,700	ton	$264	$976,800
TRBG Soil Excavation	2,776	ton	$264	$732,864
Delineation Sampling Soil Waste Disposal	3	ea	$1,652	$3,175
Decontamination Water Sampling	5	ea	$967	$4,835
Decontamination Water Disposal	275	gal	$2.50	$4,672

NASA Glenn Research Center at Neil A. Armstrong Test Facility
Feasibility Study - Soil at NASA GRC-ATF Burning Grounds
Alternative 2: Excavation and Off-Site Disposal - Attain Residential Land Use
Budgetary Cost Estimate

Capital Cost				**$3,233,451**
Activity	**Quantity**	**Unit**	**Unit Cost**	**Total**
Site Restoration				
Backfill - Common fill				
FRBG Backfill (material only)	75	ton	$22	$1,650
SRBG Backfill (material only)	1,887	ton	$22	$41,514
TRBG Backfill (material only)	672	ton	$22	$14,784
Backfill - Hydric soil/Topsoil (material only)				
FRBG topsoil (material only)	25	ton	$36	$900
SRBG topsoil (material only)	1,813	ton	$36	$65,268
TRBG topsoil (material only)	2,105	ton	$36	$75,780
Excavation Backfilling and Soil Compaction				
FRBG Backfill Compaction	56	CY	$10	$560
SRBG Backfill Compaction	2,056	CY	$10	$20,560
TRBG Backfill Compaction	1,543	CY	$10	$15,430
Topsoil Placement and Seeding				
FRBG Topsoil and Seeding	69	SY	$12	$828
SRBG Topsoil and Seeding	2,569	SY	$12	$30,833
TRBG Topsoil and Seeding	1,206	SY	$12	$14,467
Backfill and Topsoil Characterization	2	ea	$540	$1,080
SWPPP Inspection	10	hr	$70	$700
Reporting				
Removal Action Completion Report	1	ea	$25,500	$25,500
Subtotal				**$2,383,145**
Contingency			10%	$238,314
Office Overhead			5%	$119,157
Information/Database Management			3%	$71,494
Construction Management			10%	$238,314
Subtotal				$3,050,425
Profit			6%	$183,026
Total Capital Cost				**$3,233,451**
Operation & Maintenance Cost				
None				

Notes:
1. Individual Unit (e.g. acre, each, day, ton) Costs based on project experience, vendor quotes, and costing tools (e.g. RSMeans).
2. The remedial cost estimated is expected to be within -30% to +50% (USEPA).

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Feasibility Study - Soil at NASA GRC-ATF Burning Grounds
Alternative 2: Excavation and Off-Site Disposal - Attain Residential Land Use
Excavation Volume Estimates

Fox Road Burning Ground	Depth bgs (ft)	Width (ft)	Length (ft)	Area (SF)	Volume (CY)	Contingency (CY)[1]	Total Volume (CY)	Tons *	Notes
Soil hotspot excavation (FRBG-SL-024)	2	25	25	625	46.30	9.26	55.56	100	ACM removal, per NASA's direction.
			Subtotal	**625**	**46.30**	**9.26**	**56**	**100**	
Snake Road Burning Ground	**Depth bgs (ft)**	**Width (ft)**	**Length (ft)**	**Area (SF)**	**Volume (CY)**	**Contingency (CY)[1]**	**Total Volume (CY)**	**Tons ***	**Notes**
Soil hotspot excavation (SRBG-SL-002)	2	75	75	5,625	416.67	83.33	500	900	HHRA COCs: PCBs and Silver Hot spot excavations based on PCB and silver exceedances at specific depths and locations. ACM removal, per NASA's direction.
Soil hotspot excavation (SRBG-SL-009)	2	75	75	5,625	416.67	83.33	500	900	
Soil hotspot excavation (SRBG-SL-001)	2	75	75	5,625	416.67	83.33	500	900	ERA COCs: Cadmium; lead; mercury; PCB-1260 ; and 2,6-DNT. Hot spot excavations based COC exceedances at specific depths and locations. ACM removal, per NASA's direction.
Soil hotspot excavation (SRBG-SL-003, SRBG-SL-004)	2	50	125	6,250	462.96	92.59	555.56	1,000	
			Subtotal	**23,125**	**1,712.96**	**342.59**	**2,056**	**3,700**	
Taylor Road Burning Ground	**Depth bgs (ft)**	**Width (ft)**	**Length (ft)**	**Area (SF)**	**Volume (CY)**	**Contingency (CY)[1,2]**	**Total Volume (CY)**	**Tons ***	**Notes**
Soil hotspot excavation (TRBG-SL-002)	6	50	50	2,500	555.56	244.44	800	1,440	COC: PCBs Hot spot excavations based on PCB exceedances at specific depths and locations. ACM removal, per NASA's direction.
Soil hotspot excavation (TRBG-SL-001, TR-6)	2	50	125	6,250	462.96	92.59	555.56	1,000	
Soil hotspot excavation (TRBG-SDSW-004)	2	30	70	2,100	155.56	31.11	186.67	336	
			Subtotal	**10,850**	**1,174**	**368.15**	**1,543**	**2,776**	
							3655	**6,576**	

Notes

*Assumes density of soil at 1.8 tons/CY.

[1] Includes 20% contingency to account for potential over-excavation.

[2] Includes additional 20% soil for excavation slope at TRBG-SL-002.

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ACRONYMS AND ABBREVIATIONS

ACM	Asbestos Containing Material
COMETS	Construction, Maintenance, Environmental and Testing Services
CY	Cubic Yard
DGA	Dense Grade Aggregate
2,6-DNT	2,6-Dinitrotoluene
ea	Each
FRBG	Front Road Burning Ground
HASP	Health and Safety Plan
hr	hour
LF	Linear Feet
MSA	Master Service Agreement
NASA	National Aeronautics and Space Administration
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyl
PFAS	per- and polyfluorinated alkyl substances
QC	Quality Control
SF	Square Feet
SRBG	Snake Road Burning Ground
SVOC	Semivolatile Organic Compound
SWPPP	Storm Water Pollution Prevention Plan
SY	Square Yard
TCLP	Toxicity Characteristic Leaching Procedure
TRBG	Taylor Road Burning Ground
VOC	Volatile Organic Compound
USEPA	United States Environmental Protection Agency

REFERENCES

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