Explanation of Significant Differences for the
Record of Decision for the Soils Operable Unit

Luckey Site

Luckey, Ohio

Authorized under the Formerly Utilized Sites Remedial Action Program

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Acronyms

3-D  three-dimensional
AEC  Atomic Energy Commission
ANL  Argonne National Laboratory
ARARs  applicable or relevant and appropriate requirements
BAASS  Bayesian Approaches for Adaptive Spatial Sampling
Be  beryllium
BBC  Brush Beryllium Company
CERCLA  Comprehensive Environmental Response, Compensation, and Liability Act
CFR  Code of Federal Regulations
COCs  constituents of concern
CSRA  cost and schedule risk analysis
ESD  explanation of significant differences
FS  feasibility study
FUSRAP  Formerly Utilized Sites Remedial Action Program
ICSM  initial conceptual site model
IPR  Industrial Properties Recovery, LLC
MARSSIM  *Multi-Agency Radiation Survey and Site Investigation Manual*
mg/kg  milligrams per kilogram
mrem/yr  millirems per year
NCP  National Oil and Hazardous Substances Pollution Contingency Plan
NRC  Nuclear Regulatory Commission
OAC  Ohio Administrative Code
ODH  Ohio Department of Health
Pb  lead
pCi/g  picocuries per gram
Ra  radium
Ra-226  radium-226
RBCs  risk-based concentrations
RI  remedial investigation
ROD  record of decision
SESOIL  SEasonal SOIL
SOR  sum of the ratios
Th  thorium
Th-230  thorium-230
U  uranium
U-234  uranium-234
U-238  uranium-238
USACE  United States Army Corps of Engineers
USAGC  United States Army Geospatial Center
1 Introduction

The Formerly Utilized Sites Remedial Action Program (FUSRAP) was initiated in 1974 to identify, investigate, and if necessary, clean up or control sites throughout the United States that were contaminated as the result of activities conducted in support of the nation’s early atomic energy and weapons programs during the 1940s, 1950s, and 1960s. The United States Army Corps of Engineers (USACE) executes FUSRAP subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). In accordance with the phased process required by CERCLA and the NCP, USACE has completed a remedial investigation (RI), feasibility study (FS), proposed plan, and two records of decision (ROD) for the Luckey Site, located in Luckey, Ohio.

On July 26, 2006, USACE signed the Record of Decision for Soils Operable Unit, Luckey Site, Luckey, Ohio. The ROD identifies beryllium (Be), lead (Pb), radium-226 (Ra-226), thorium-230 (Th-230), uranium-234 (U-234) and uranium-238 (U-238) as FUSRAP-related constituents of concern (COCs) in soils. In the ROD, USACE determined that Title 10, Part 20, Subpart E of the Code of Federal Regulations (10 CFR Part 20 Subpart E), Ohio Administrative Code 3701:1-38-22 (OAC 3701:1-38-22), and Section 403 of the Toxic Substances Control Act were applicable or relevant and appropriate requirements (ARARs) for the site. The remedy for soils is the excavation and off-site disposal of FUSRAP-contaminated materials.

In 2008, USACE signed a ROD addressing uranium, Pb, and Be contamination that currently exists in groundwater below the site. The remedy for groundwater is monitored natural attenuation.

Between November 2009 and April 2010, USACE performed additional environmental sampling to address data gaps and reduce uncertainty regarding the vertical and horizontal extent of FUSRAP-related contaminated soils (USACE 2011). Additionally, the U.S. Army Geospatial Center (USAGC) performed a review of historical aerial photographs for the Luckey Site (USAGC 2011).

Argonne National Laboratory (ANL) and USACE used the results of both studies to update the FUSRAP-related contaminated soil volume estimate. The revised contaminated soil volume estimate is larger than the ROD estimate. Additionally, sampling data indicates that FUSRAP-contaminated soils are located under a former annex building, and volume estimation modeling indicates that FUSRAP-contaminated soils may be located under a portion of a former production building. The contaminated soils under the buildings, which were active production facilities, were not originally included in the estimated volume of soils to be addressed under the ROD. The Luckey Site buildings, which are now vacant and partially demolished, will be removed as necessary to access detected contaminated soils beneath.

Further, several work items from the cost estimate were reexamined and their costs were increased based on lessons learned from other FUSRAP remedial actions and updated cost data. The current cost estimate for the soils remedy of $244.0 million is a significant change over the ROD cost estimate of $59.4 million.
In light of the new information and changed circumstances at the Luckey Site, USACE is issuing this explanation of significant differences (ESD) in accordance with Section 117(c) of CERCLA, as amended [42 United States Code § 9617(c)], and Section 300.435(c)(2)(i) and 300.825(a)(2) of the NCP. The NCP requires that a lead agency document changes made during a remedial action, when such action differs significantly from the remedy selected in the ROD. The lead agency is also required to make the ESD available to the public. The lead agency for this site is USACE.

The administrative record file, which contains this ESD, ROD, and other information used to prepare them, is available at the following locations:

Luckey Public Library
228 Main Street
Luckey, OH 43443
Phone: 419-833-6040

Monday: 9:00 AM - Noon then 3:30 PM - 7:30 PM (Summer Hours)
Tuesday: 3:30 PM - 7:30 PM
Wednesday: 3:30 PM - 7:30 PM
Thursday: 3:30 PM - 7:30 PM
Saturday: 10 AM - 12 PM

U.S. Army Corps of Engineers
Public Information Center
1776 Niagara Street
Buffalo, NY 14207-3199
Phone: 800-833-6390 (Option 4)

Available Monday through Friday 8:30-4:00, closed on federal holidays

2 Site History and Selected Remedy

2.1 Site History

The Luckey Site is located at 21200 Luckey Road in Luckey, Ohio. The village of Luckey, Ohio, is 22 miles southeast of Toledo (Figure 1) and has a population of approximately 1,500. The property is approximately 40 acres in size and is located on the corner of Gilbert and Luckey Roads in Wood County (Figure 2). In 1942, the Defense Plant Corporation built a magnesium production plant at the Luckey Site to produce metallic magnesium. In November 1945, the magnesium production plant was closed as a war surplus plant.

Custody of the Luckey facility was transferred to the Reconstruction Finance Corporation in 1945. As early as 1946, Brush Beryllium Company (BBC), as a contractor to the Atomic Energy Commission (AEC), was allowed to use equipment from the Luckey plant in pilot projects. In 1949, BBC leased the entire site and contracted with the AEC to design, construct, operate, and maintain the Luckey plant for the production of beryllium. The company also agreed to maintain the former magnesium plant facilities in standby status. The beryllium production facilities were owned by the AEC and operated by BBC from 1949 to 1958. The plant produced mostly
beryllium hydroxide, in addition to some beryllium metal in vacuum-cast billets and beryllium oxide (from beryllium hydroxide). The company transferred beryllium production operations to a new facility located in Elmore, Ohio, in 1958. Sintering and powder blending operations, established at the Luckey facility in 1957, continued through the early 1960s, and then were shut down.

The sources of contamination at the Luckey Site include raw materials brought to the site for processing and byproducts generated during site operations.

The Luckey Site received approximately 1,000 tons of scrap steel from the Lake Ontario Storage Area, located in Niagara County, New York, in late 1951. The scrap steel was reported to contain radioactive materials including Ra-226, Th-230, U-234, and U-238. It was stored in the yard north of the production building along railroad tracks. Records also indicate beryllium scrap from other AEC operations was sent to Luckey for reprocessing, and some of this scrap was contaminated with radionuclides.

Waste disposal activities associated with the beryllium production facilities involved the use of lagoons in the southern portion of the site (Lagoons A, B, and C) and trenches in the northeast corner of the site. These locations are shown in Figure 3. They were used for disposal of process-related wastes during beryllium production as well as for disposal of materials during the plant closing. In 1959, the AEC contracted BBC to close the plant. The burial site used for closure activities, located in the northeast corner of the site, is identified as the disposal area in Figure 3.

The current property owner, Industrial Properties Recovery, LLC (IPR), an industrial scrapping business, purchased the property in 2006. Shortly thereafter, IPR began demolishing several ancillary buildings including the former annex building (Figure 3). During December 2006, the Ohio Department of Health (ODH) issued an Emergency Adjudication Order to IPR to cease the demolition of buildings and handling of any radioactive material.

The Wood County Combined General Health District deemed the site a public health and safety concern, and the Wood County Court issued an injunction against IPR in June 2009. The injunction required IPR to either demolish or make necessary repairs to site structures and salvage or properly dispose of all debris, rubbish, and garbage. The company resumed demolition and salvage activities during late 2013, including partial demolition of the former production building. In December 2013, the ODH issued another Emergency Adjudication Order to IPR, to cease the removal of material from the site unless it has been confirmed as not having radioactive contamination. In January 2014, the Ohio Environmental Protection Agency issued a Final Findings and Order to IPR, to halt demolition of site buildings until they comply with Ohio asbestos and air quality regulations.

Of the former annex building, the building slab, loading dock, and a majority of debris from the demolition remain. The former production building and other site buildings are in various stages of demolition or disrepair.

2.2 Selected Remedy

In accordance with the phased process required by CERCLA and the NCP, USACE has completed a RI, FS, proposed plan, and two RODs for the Luckey Site. The Record of Decision
for Soils Operable Unit, Luckey Site, Luckey, Ohio, was signed by USACE on July 26, 2006. Text below that describes the remedy has not been reproduced verbatim (i.e., as it appears in the ROD). The text was edited to clarify the intent of the ROD, with respect to the differences between radionuclide constituents of concern (COCs) and beryllium and lead. No changes to scope or the performance of the remedy are proposed within this ESD.

The remedy selected to address impacted soils at the Luckey Site is excavation of soils and off-site disposal. Impacted soils will be excavated to achieve cleanup goals for unrestricted use. The critical group has been identified as the subsistence farmer for the Luckey Site. Cleanup goals will be used as target concentrations of FUSRAP-related COCs that may remain. In addition, not-to-exceed concentrations will be developed to ensure no localized areas remain that potentially pose an unacceptable risk.

Excavated soils will be shipped off-site for disposal at a licensed/permitted disposal facility. This selected alternative ensures compliance with the ARARs, since soils will be removed from the Luckey Site to meet cleanup goals for unrestricted use by the critical group. Complete removal also precludes further potential for contamination of the groundwater system.

The USACE determined the Nuclear Regulatory Commission (NRC) standards for decommissioning of licensed facilities found in 10 CFR Part 20 Subpart E and OAC 3701:1-38-22 are relevant and appropriate for the remediation of FUSRAP-related COCs in impacted soils at the Luckey Site. The OAC 3701:1-38-22 contains the same provisions as 10 CFR Part 20 Subpart E.

In compliance with these standards, USACE will:

1. Use cleanup goals stated in Table 1 as mean concentrations of COCs that may remain at the Luckey Site.
2. Develop not-to-exceed concentrations (sometimes expressed as elevated measurement comparison or EMC) for the radionuclide COCs to ensure no small, discrete area of elevated activity will produce an unacceptable dose. The confirmation methodology and not-to-exceed concentrations will be developed in the detailed remedial design.
3. Demonstrate compliance with radionuclide soil cleanup goals using surveys developed in accordance with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).
4. Develop a complementary compliance verification methodology for beryllium and lead. The 95 percent upper confidence limit of the mean (residual) concentration will conservatively be used to compare to the concentrations in Table 1.
5. Develop all verification methodologies in accordance with the ARARs and document them in the remedial design.
6. Remove and dispose off-site all impacted soils (on-site and contiguous to the site) excavated to achieve cleanup goals, as discussed above, for FUSRAP-related COCs.
Table 1. COCs and Cleanup Goals for Impacted Soils at the Luckey Site

<table>
<thead>
<tr>
<th>Receptors</th>
<th>COC</th>
<th>Cleanup Goal(^a)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsistence Farmer</td>
<td>Beryllium</td>
<td>131 mg/kg</td>
<td>RBC</td>
</tr>
<tr>
<td></td>
<td>Lead</td>
<td>400 mg/kg</td>
<td>ARAR</td>
</tr>
<tr>
<td></td>
<td>Radium-226</td>
<td>2.0 pCi/g(^b)</td>
<td>ARAR</td>
</tr>
<tr>
<td></td>
<td>Thorium-230</td>
<td>5.8 pCi/g(^b)</td>
<td>ARAR</td>
</tr>
<tr>
<td></td>
<td>Uranium-234</td>
<td>26 pCi/g(^b)</td>
<td>ARAR</td>
</tr>
<tr>
<td></td>
<td>Uranium-238</td>
<td>26 pCi/g(^b)</td>
<td>ARAR</td>
</tr>
</tbody>
</table>

\(^a\) SEasonal SOIL(SESOIL\(^\text{®}\)), a one-dimensional vertical transport screening-level model for the unsaturated (vadose) zone, modeling results confirm that risk-based concentrations (RBCs) and ARAR-based cleanup goals selected for soils will also be protective of groundwater.

\(^b\) Soil cleanup goals for radionuclides represent activity levels above average site background activity corresponding to 25 millirem per year (mrem/yr) (10 CFR Part 20 Subpart E and OAC 3701:1-38-22). If a mixture of radionuclides is present, then the sum of ratios (SOR) applies per MARSSIM and the ratio should not exceed unity. For example, use the 25 mrem/yr cleanup goals for unrestricted use by the critical group, which has been identified as the subsistence farmer for the Luckey Site, for soil to generate the following sum of the ratios equation:

\[
SOR = \frac{Ra_{226}}{2.0 \text{ pCi/g}} + \frac{Th_{230}}{5.80 \text{ pCi/g}} + \frac{U_{234}}{26 \text{ pCi/g}} + \frac{U_{238}}{26 \text{ pCi/g}}
\]

where: \(SOR\) = sum of the ratios result  
\(Ra_{226}\) = net Radium-226 soil concentrations  
\(Th_{230}\) = net Thorium-230 soil concentrations  
\(U_{234}\) = net Uranium-234 soil concentrations  
\(U_{238}\) = net Uranium-238 soil concentrations  

Net soil concentrations exclude site background contribution.

\(mg/kg\) – milligrams per kilogram  
\(pCi/g\) – picocuries per gram

3 Basis for This Document

3.1 Summary of Additional Information

During the USACE RI and selection of the remedy, the facilities at the Luckey Site were occupied and operational. Contamination beneath the buildings was not investigated and not included in the original volume estimates. Since 2006, the facilities have been unoccupied. As such, between November 2009 and April 2010, USACE performed additional environmental sampling to address data gaps and reduce uncertainty regarding the vertical and horizontal extent of FUSRAP-related contaminated soils (USACE 2011). Additionally, the USAGC performed a review of historical aerial photographs for the Luckey Site (USAGC 2011).
The results of both studies were used by ANL and USACE to update the FUSRAP-related contaminated soil volume estimates. The revised contaminated soil volume estimate is larger than the ROD estimate. Additionally, sampling data indicates that FUSRAP-contaminated soils are located under the former annex building, and volume estimation modeling indicates that FUSRAP-contaminated soils are potentially located under a portion of the former production building. The Luckey Site buildings, which are now vacant and partially demolished, will be removed as necessary to access detected contaminated soils beneath.

The 2006 ROD excluded any CERCLA action to address the site buildings since there had been no evidence of a release from the buildings, as defined by CERCLA, nor evidence of a substantial threat of a release of hazardous substances into the environment from the buildings that would warrant a CERCLA response action. Since the signing of the ROD, the Luckey Site buildings are no longer occupied, and the current owner has completed some demolition activities. Additionally, as shown on Figures 4 and 5, FUSRAP-contaminated soils are located beneath the former annex building, and are modeled to be located under a portion of the former production building. The USACE now anticipates completing demolition activities necessary to access FUSRAP-contaminated soils beneath Luckey Site buildings. The buildings will only be removed if investigative, preexcavation sampling during the site remediation confirms that FUSRAP-related contamination extends beneath them.

Most of the former annex building has been demolished; however, the loading dock and the majority of the debris from demolition of the annex remain in place.

### 3.2 Waste Volumes

#### 3.2.1 Soil

Contaminated soil volumes at the Luckey Site were estimated using a method developed by ANL known as the Bayesian Approaches for Adaptive Spatial Sampling (BAASS), which uses both “hard” and “soft” data to generate a probability that a given area will exceed cleanup levels (ANL 2005). A description of the initial conceptual site model, data evaluation, and BAASS methodology used for the site is provided in Appendix A.

Seven different potential soil waste streams are anticipated:

- Soil contaminated solely with Be (Be concentration exceeds 131 mg/kg).
- Soil contaminated solely with radionuclides (SOR greater than 1.0).
- Soil contaminated with radionuclides and Be (SOR greater than 1.0 and Be concentration exceeds 131 mg/kg).
- Soil contaminated solely with Pb (Pb concentration exceeds 400 mg/kg).
- Soil contaminated with Pb and Be (Pb concentration exceeds 400 mg/kg and Be concentration exceeds 131 mg/kg).
- Soil contaminated with radionuclides and Pb (SOR greater than 1.0 and Pb concentration exceeds 400 mg/kg).
- Soil contaminated with radionuclides, Pb, and Be (SOR greater than 1.0, Pb concentration exceeds 400 mg/kg, and Be concentration exceeds 131 mg/kg).
Depending on the selected disposal facility or facilities, these are likely to be consolidated into four soil waste streams:

- Soil contaminated solely with Be.
- Radionuclide-contaminated soil that may or may not contain Be.
- Pb-contaminated soil that may or may not contain Be.
- Radionuclide and Pb-contaminated soil that may or may not contain Be.

Table 2 summarizes in situ and ex situ contaminated soil volume estimates for each of the four likely soil waste streams and potentially clean cutback soils for the Luckey Site. The in situ and ex situ contaminated soil volumes as calculated in the ROD are provided for comparison. Figure 4 illustrates the modeled lateral extent of the in situ FUSRAP-related contaminated soils/fill/debris. Figure 5 illustrates the modeled lateral extent of the FUSRAP-related contaminated soils, fill, and debris found in trenches or other site soils.

Table 2. Contaminated and Excavation Soil Volume Estimate for the Luckey Site

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil contaminated solely with Be</td>
<td>35,450</td>
<td>56,150</td>
<td>28,979</td>
<td>36,224</td>
</tr>
<tr>
<td>Radionuclide-contaminated soil that may or may not contain Be</td>
<td>16,000</td>
<td>25,350</td>
<td>56,769</td>
<td>70,961</td>
</tr>
<tr>
<td>Radionuclide and Pb-contaminated soil that may or may not contain Be</td>
<td>2,500</td>
<td>3,950</td>
<td>15,246</td>
<td>19,058</td>
</tr>
<tr>
<td>Pb-contaminated soil that may or may not contain Be</td>
<td>1,450</td>
<td>2,300</td>
<td>2,898</td>
<td>3,622</td>
</tr>
<tr>
<td>Contaminated Soil Totals</td>
<td>55,400</td>
<td>87,750</td>
<td>103,892</td>
<td>129,865</td>
</tr>
<tr>
<td>Potentially Clean Cutback Soils</td>
<td>0</td>
<td>0</td>
<td>6,082</td>
<td>7,602</td>
</tr>
<tr>
<td>Excavation Totals</td>
<td>55,400</td>
<td>87,750</td>
<td>109,974</td>
<td>137,467</td>
</tr>
</tbody>
</table>

All volumes are expressed in cubic yards.

a. ROD ex situ volume includes ROD in situ volume plus 20 percent over excavation, 10 percent constructability (cutback soils), and 20 percent swell (bulking) factor.

b. ESD ex situ volume includes ESD in situ volume plus 25 percent bulking factor. No over excavation is assumed and the cutback soils are assumed to be potentially clean.
3.2.2 Building Debris

Contaminated debris volumes at the Luckey Site were estimated using engineering judgment and general building formulas from *Debris Estimating Field Guide* (FEMA 2010). Radiation surveys conducted during the FUSRAP remedial investigation found areas within the former production and annex buildings with elevated radioactivity, the majority of which were in the ceiling beams. Beryllium sampling conducted during the remedial investigation found beryllium surface and dust contamination, as well as beryllium in some of the building materials (e.g., paint, brick, concrete, etc.), in the former production and annex buildings. Based on this information, five different debris waste streams are anticipated:

- Debris contaminated solely with Be.
- Debris contaminated with radionuclides that may or may not contain Be.
- Debris contaminated with Pb that may or may not contain Be.
- Debris contaminated with radionuclides and Pb that may or may not contain Be.
- Asbestos-containing material.

Table 3 summarizes the estimated volume of contaminated building debris that may be removed, which includes the remains of the former production and annex buildings.

**Table 3. Contaminated Building Debris Volume Estimate for the Luckey Site**

<table>
<thead>
<tr>
<th>Debris Categorization</th>
<th>Assumed Percentagea</th>
<th>Volumeb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debris contaminated solely with Be</td>
<td>50</td>
<td>23,929</td>
</tr>
<tr>
<td>Radionuclide-contaminated debris that may or may not contain Be</td>
<td>20</td>
<td>9,571</td>
</tr>
<tr>
<td>Pb-contaminated debris that may or may not contain Be</td>
<td>10</td>
<td>4,786</td>
</tr>
<tr>
<td>Radionuclide- and Pb-contaminated debris that may or may not contain Be</td>
<td>10</td>
<td>4,786</td>
</tr>
<tr>
<td>Asbestos-containing material</td>
<td>10</td>
<td>4,786</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>100</strong></td>
<td><strong>47,858</strong></td>
</tr>
</tbody>
</table>

*All volumes are expressed in cubic yards.*

*a. Engineering judgment based on review of the Luckey RI  
b. Volume estimated determined using General Building formulas from “FEMA 329 Debris Estimating Field Guide” (FEMA 2010))*

For purposes of preparing the updated cost estimate it was conservatively assumed that all of the building debris would require off-site disposal at the same disposal facility as the soils. Release and recycling criteria for building materials will be developed during preparation of the
remediation work plans, if it is determined that recycling or other alternatives to off-site disposal are viable.

3.3 Updates to the Remedial Action Cost Estimate

The cost estimate to complete the Luckey Site soils remedial action, as presented in the ROD, was prepared from the FS (USACE 2003). The ROD non-discounted cost estimate was $36.5 million in fiscal year 2002 dollars. This equates to $59.4 million in fiscal year 2014 dollars.

The USACE revised the cost estimate to include:

- The updated volume estimates.
- Demolition and disposal of the former production and annex buildings.
- Work items excluded in the FS, including the treatment of water collected in open excavations.
- Increases to work item costs under estimated in the FS based on lessons learned from other FUSRAP remedial actions, including:
  - Monitoring, sampling, testing, and analysis.
  - Wastewater collection and control.
  - Site restoration activities.
  - Contractor general requirements.
  - USACE supervision and administration.
- Fiscal year 2014 cost data.
- Use of a cost and schedule risk analysis methodology to develop a risk-based cost contingency.

The current non-discounted cost estimate is $244.0 million (fiscal year 2014 dollars). See Appendix B for the basis of estimate and current working estimate summaries, and Appendix C for a description of the cost and schedule risk analysis process.

4 Description of Significant Differences

The COCs, site area, and reasonable future land use have not changed; however, the cost of the remedy has increased. The current cost estimate for the soils remedy of $244.0 million is a significant change over the ROD cost estimate of $59.4 million.

This cost increase is attributed to an increase in the estimated volume of contaminated soil. Additionally, the contaminated soil footprint is now projected to extend beneath at least two unoccupied site buildings, which would require removal in order to fully address the soil contamination. Further, several work items were reexamined and their costs were increased based on lessons learned from other FUSRAP remedial actions and updated cost data.

The selected remedy remains excavation with off-site disposal of soils contaminated with FUSRAP-related materials, with no change in the cleanup goals, long-term reliability of the remedy, or the state and community preferences.

5 Statutory Determinations
The selected remedy is protective of human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to hazardous substances that are part of this response action, and is cost effective.

6 Public Participation Compliance

In accordance with Section 300.435 (C)(2)(ii) of the NCP, a notice briefly summarizing the ESD will be published in *The Blade* (Toledo) and the *Sentinel-Tribune* (Bowling Green).
7 References


Figures
LUCKEY FUSRAP SITE
LUCKEY, OHIO

FIGURE 1

Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community
Appendix A: Contaminated Soil Volume Estimate
Appendix A – Contaminated Soil Volume Estimate

A1 Method

The United States Army Corps of Engineers (USACE) and Argonne National Laboratory (ANL) utilized a method developed by ANL to estimate contaminated soil volumes at the Luckey Site. The method, known as the Bayesian Approaches for Adaptive Spatial Sampling (BAASS), uses both “soft” and “hard” data to generate a probability that a given area will exceed constituent of concern (COC) cleanup goals (ANL 2005).

Soft data includes aerial photographs, nonintrusive geophysics, gamma walkover surveys, laser-induced breakdown spectroscopy data, anecdotal information, and historical site/process knowledge. This information was used to create an initial conceptual site model (ICSM). After each ICSM was entered into the BAASS software, hard data (site characterization results) were input and the ICSM was updated. The results of the BAASS model were then exported to ArcGIS™ (geographic information system software produced by the Environmental Systems Research Institute), which was used to convert the BAASS output into confidence contours, or two-dimensional areas that were greater than or equal to a certain probability of exceeding the COC cleanup goals. Table A-1 presents potential probability contours that are generated based upon the BAASS Output.

Table A-1. Probability Contours Generated by BAASS

<table>
<thead>
<tr>
<th>Confidence Level</th>
<th>BAASS Probability</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>90%</td>
<td>0.1</td>
<td>90% confidence the area includes all soil that exceeds cleanup goals (largest extent)</td>
</tr>
<tr>
<td>70%</td>
<td>0.3</td>
<td>70% confidence the area includes all soil that exceeds cleanup goals</td>
</tr>
<tr>
<td>50%</td>
<td>0.5</td>
<td>50% confidence the area includes all soil that exceeds cleanup goals</td>
</tr>
<tr>
<td>30%</td>
<td>0.7</td>
<td>30% confidence the area includes all soil that exceeds cleanup goals</td>
</tr>
<tr>
<td>10%</td>
<td>0.9</td>
<td>10% confidence the area includes all soil that exceeds cleanup goals (smallest extent)</td>
</tr>
</tbody>
</table>

The BAASS software simulation addressed only the lateral extent (i.e., the area) of contamination based on the ICSM and site characterization data. To convert areas to in situ contaminated soil volumes, estimates of maximum depths of contamination that exceeded the COC cleanup goals were used to calculate the three-dimensional (3-D) volume of contaminated soil within each area. The depth estimates were derived from site characterization results and historical information regarding the depth of disposal trenches.

The risk-neutral 50 percent confidence level, or 0.5 BAASS probability level, contaminated soil volume was selected for cost estimating purposes in the explanation of significant differences (ESD). The in situ contaminated soil volume was then used to develop an in situ construction soil volume, which represents the maximum excavation footprint required to access and remove contaminated material associated with the specified confidence interval. It includes removal of uncontaminated overburden to access contaminated soils and sloping/benching (where required) to ensure worker safety.
Appendix A – Contaminated Soil Volume Estimate

A2 Initial Conceptual Site Model

A BAASS analysis requires developing an ICSM for the site. For the Luckey Site, three ICSMs were created for:

- Radionuclides in soil, based on the sum of the ratios (SOR) (≥ 1.0).
- Beryllium (Be) in soil (≥ 131 mg/kg).
- Lead (Pb) in soil (≥ 400 mg/kg).

The ICSMs captured the soft information for a particular area as probabilities of contamination. They present an understanding, absent of sampling data, of where contamination is likely to be found. The contamination probability was captured by a set of grid points overlain on the area of interest; the probability of contamination in an ICSM can and often does vary from grid point to grid point.

Soft data for the Luckey Site included aerial photographs, non-intrusive geophysics, gamma walkover surveys, laser-induced breakdown spectroscopy data, anecdotal information, and historical site/process knowledge. Based on available soft information, individual grid nodes were assigned various contamination probabilities. The ICSM and BAASS grid nodes are illustrated in Figure A-1.

A3 Data Evaluation

The soil analytical data used to generate the volume estimate was compiled from two USACE investigation data sets:

- A remedial investigation (RI) that included U.S. Department of Energy radiological survey data (1990), USACE Phase II characterization data (1997), and USACE RI data (1998).
- Sampling and analysis conducted in 2009 and 2010 as part of an excavation volume uncertainty investigation (USACE 2011).

An SOR was calculated for each soil sample utilizing radium-226 (Ra-226), thorium-230 (Th-230), uranium-234 (U-234), and uranium-238 (U-238) results (only Ra-226 results were used when the other isotope analytical data was unavailable). The SOR was calculated using the data set specific arithmetic mean (average) background values and COC cleanup goals presented in Table A-2.
Appendix A – Contaminated Soil Volume Estimate

Table A-2. COCs and Cleanup Goals for Impacted Soils at the Luckey Site

<table>
<thead>
<tr>
<th>Receptors</th>
<th>COC</th>
<th>Cleanup Goal(^a)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsistence Farmer</td>
<td>Beryllium</td>
<td>131 mg/kg</td>
<td>RBC</td>
</tr>
<tr>
<td></td>
<td>Lead</td>
<td>400 mg/kg</td>
<td>ARAR</td>
</tr>
<tr>
<td></td>
<td>Radium-226</td>
<td>2.0 pCi/g(^b)</td>
<td>ARAR</td>
</tr>
<tr>
<td></td>
<td>Thorium-230</td>
<td>5.8 pCi/g(^b)</td>
<td>ARAR</td>
</tr>
<tr>
<td></td>
<td>Uranium-234</td>
<td>26 pCi/g(^b)</td>
<td>ARAR</td>
</tr>
<tr>
<td></td>
<td>Uranium-238</td>
<td>26 pCi/g(^b)</td>
<td>ARAR</td>
</tr>
</tbody>
</table>

\( a. \) SEasonal SOIL (SESOIL\(^\circledR\)), a one-dimensional vertical transport screening-level model for the unsaturated (vadose) zone, modeling results confirm that risk-based concentrations (RBCs) and ARAR-based cleanup goals selected for soils will also be protective of groundwater.

\( b. \) Soil cleanup goals for radionuclides represent activity levels above average site background activity corresponding to 25 millirem per year (mrem/yr) (10 CFR Part 20 Subpart E and OAC 3701:1-38-22). If a mixture of radionuclides is present, then the sum of ratios (SOR) applies per MARSSIM and the ratio should not exceed unity. For example, use the 25 mrem/yr cleanup goals for unrestricted use by the critical group, which has been identified as the subsistence farmer for the Luckey Site, for soil to generate the following sum of the ratios equation:

\[
SOR = \frac{Ra_{226}}{2.0 \text{ pCi/g}} + \frac{Th_{230}}{5.80 \text{ pCi/g}} + \frac{U_{234}}{26 \text{ pCi/g}} + \frac{U_{238}}{26 \text{ pCi/g}}
\]

where: 
- \( SOR = \) sum of the ratios result
- \( Ra_{226} = \) net Radium-226 soil concentrations
- \( Th_{230} = \) net Thorium-230 soil concentrations
- \( U_{234} = \) net Uranium-234 soil concentrations
- \( U_{238} = \) net Uranium-238 soil concentrations

Net soil concentrations exclude site background contribution.

mg/kg – milligrams per kilogram

pCi/g – picocuries per gram

The COC site background concentrations listed in the ROD were calculated using the 95 percent upper tolerance limit of the background data set. Using the arithmetic mean of the background data results in values that are more representative of the average site background concentrations, and are lower than those calculated using the 95 percent upper tolerance limit. This subsequently reduces the gross concentrations of the COCs that will meet the cleanup goals, resulting in a more conservative SOR calculation and soil volume estimate. After subtracting average background, each radionuclide result was divided by its respective cleanup goal. The fractions were then summed to obtain a final SOR for each sample. A sample with an SOR greater than 1.0 was considered to “fail” and require remediation.

Where multiple samples were collected at various depths from a single location, the maximum SOR value was used regardless of the depth at which it occurred since BAASS can only handle one input for each unique location. USACE ensured a more conservative approach to volume
Appendix A – Contaminated Soil Volume Estimate

estimating in this manner. Sample locations with a SOR greater than or equal to 1.0 were assigned a contaminant weighting of 1 in the BAASS software. Those with a SOR below 1.0 were assigned a value of 0.

The Be and Pb results were compared to their respective cleanup goals. Sample locations with a result greater than the cleanup goal were considered to “fail” and require remediation (i.e., assigned a value of 1). Similar to the SOR, where multiple samples were collected at various depths from a single location, the maximum Be or Pb value was used regardless of the depth at which it occurred.

A4 Bayesian Approaches for Adaptive Spatial Sampling

BAASS requires three additional key parameters: a variogram1 function, the range for the variogram selected, and a search neighborhood. The variogram functional form combined with its range captures beliefs about the spatial autocorrelation present. The search neighborhood determines which sampling locations can contribute to the updating process at any particular grid node. The variogram functional form and range, in conjunction with the spatial pattern of sampled locations, determines how much “weight” each sampled location has in estimating the probability of contamination at a grid node. Bayesian updating is used to merge each ICSM probability with those obtained from indicator Kriging2 of the contaminated weighting factors. For the Luckey Site, 61 meters (200 feet) was used for both the radius of the search neighborhood and for the range of the variogram. The functional form of the variogram was set to exponential. After updating, areas distant from sampled locations generally have contamination probabilities that reflect each ICSM, while densely sampled areas have probabilities that reflect the results of sampling.

A5 Lateral Extents

The output from BAASS was an updated probability for each grid node (i.e., each ICSM is updated with the hard data). The data was converted into a point file and projected onto the base map using ArcGIS™; the grid nodes could then be displayed such that the footprint for any given probability could be shown. For example, all points with a probability $\geq 0.5$ may be displayed as colored dots, while all others are not displayed. This would show the footprint for the area of the site with a BAASS probability of 0.5 or greater. To arrive at the final footprint, the grid nodes were converted into a raster data layer in order to provide a continuous surface. This raster data layer was contoured, at the specified probability, to create polygons representing the contaminated footprints. Figure A-2 presents a map of the Luckey Site with the BAASS 0.5 probability nodes and the resulting contaminated soil footprint polygons for radionuclide SOR, Be, and Pb.

The main drainage ditch, which runs north-south and extends from the northeast boundary of the Luckey Site and discharges into Toussaint Creek, was not included in the Bayesian analysis. Engineering judgment was used to estimate a volume of radionuclide and beryllium

1 A variogram is a graph that characterizes the spatial continuity or roughness of a dataset.
2 Kriging predicts the value of a function at a given point by computing a weighted average of the known values of the function in the neighborhood of the point.
Appendix A – Contaminated Soil Volume Estimate

contaminated material in this linear feature on the basis of sediment and soil samples collected from within and along the banks of the drainage ditch.

A6 Three-Dimensional Modeling

In order to generate a contamination volume, 3-D modeling was conducted using ArcGIS™ Spatial Analyst and 3-D Analyst Extensions. The 50 percent probability level contours for radionuclides (SOR), Be, and Pb were combined and used as the basis for the initial in situ contaminated soil volume (i.e., prior to excavation). This volume was further modified by incorporating engineering aspects of soil excavation, including safety sloping/benching.

The in situ contaminated soil volume was calculated by determining the top and bottom elevation of contamination at each sampling location. Little clean overburden is present at the Luckey Site so the topographic surface elevation was conservatively selected as the top elevation. The bottom elevation was set at the maximum depth below ground surface at which a sample with a SOR, Be, or Pb exceedance occurred. If SOR, Be, or Pb results were separated vertically by one or more acceptable samples, the deepest elevated sample was used to vertically bound the extent of FUSRAP-related contamination.

For unbounded sample locations within the disposal trench area located within the northeastern corner of the site, the available soft data, including geophysical surveys and anecdotal evidence regarding the depths of the disposal trenches (USACE 2000), was utilized. If a vertically unbounded sample was located within the footprint of a disposal trench, the bottom surface was the anecdotal trench depth for that sample location.

These values were used to generate 3-D surfaces utilizing ArcGIS™ 3-D Analyst to represent the simulated top and bottom of soil contaminated with radionuclides, Be, and Pb. The in situ contaminated soil volume at each excavation area was determined by calculating the difference between the bottom and top of contamination within ArcGIS™.

The cutback soil volume was determined by calculating necessary safety side slopes, based on a 2:1 horizontal to vertical slope, for all portions of the contaminated soil footprint greater than five feet in depth, per the USACE Safety and Health Requirements Manual (USACE 2008). The total in situ construction soil volume represents the sum of the cutback soil volumes and the in situ contaminated soil volumes.

The final volume resulting from this process represents the best engineering estimate of both the in situ contaminated soil and construction volumes that will be generated during excavation activities for the Luckey Site selected remedy. Because the final excavation footprints include engineering aspects of the excavation process, the associated areas and volumes are larger than the corresponding in situ contaminated areas and volumes. Figures A-3 and A-4 represent the modeled lateral extent and depth of FUSRAP-related contaminated soils/fill/debris, respectively.

Table A-3 summarizes in situ and ex situ soil volumes estimates for the four likely waste streams and potentially clean cutback soils for the site.
### Table A-3. Contaminated and Excavation Soil Volume Estimate for the Luckey Site

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil contaminated solely with Be</td>
<td>35,450</td>
<td>56,150</td>
<td>28,979</td>
<td>36,224</td>
</tr>
<tr>
<td>Radionuclide-contaminated soil that may or may not contain Be</td>
<td>16,000</td>
<td>25,350</td>
<td>56,769</td>
<td>70,961</td>
</tr>
<tr>
<td>Radionuclide and Pb-contaminated soil that may or may not contain Be</td>
<td>2,500</td>
<td>3,950</td>
<td>15,246</td>
<td>19,058</td>
</tr>
<tr>
<td>Pb-contaminated soil that may or may not contain Be</td>
<td>1,450</td>
<td>2,300</td>
<td>2,898</td>
<td>3,622</td>
</tr>
<tr>
<td><strong>Contaminated Soil Totals</strong></td>
<td><strong>55,400</strong></td>
<td><strong>87,750</strong></td>
<td><strong>103,892</strong></td>
<td><strong>129,865</strong></td>
</tr>
<tr>
<td>Potentially clean cutback soils</td>
<td>0</td>
<td>0</td>
<td>6,082</td>
<td>7,602</td>
</tr>
<tr>
<td><strong>Excavation Totals</strong></td>
<td><strong>55,400</strong></td>
<td><strong>87,750</strong></td>
<td><strong>109,974</strong></td>
<td><strong>137,467</strong></td>
</tr>
</tbody>
</table>

All volumes are expressed in cubic yards.

- <sup>a</sup> ROD ex situ volume includes ROD in situ plus 20 percent over excavation, 10 percent constructability (cutback soils), and 20 percent swell (bulking) factor.
- <sup>b</sup> Ex situ volume includes in situ volume plus 25 percent bulking factor. No over excavation is assumed and the cutback soils are assumed to be potentially clean.
Attachment 1

Figures
Appendix A – Contaminated Soil Volume Estimate

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Appendix B: Basis of Estimate and Current Working Estimate Summaries
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Alternative 5 consists of excavation of impacted soils and materials above unrestricted land-use cleanup goals and subsequent off-site disposal. The removal of impacted soils and materials will address further impacts to groundwater via leaching and/or direct contact. All AEC-related materials will be excavated to eliminate the potential for direct contact with groundwater. Soils and materials will be subjected to waste profiling to ensure compliance with the requirements of the off-site disposal facility’s waste acceptance criteria (WAC). This alternative will require close coordination of remediation and monitoring activities with the land owner(s) and/or tenants to minimize health and safety risks to on-site personnel and to minimize disruption to their activities consistent with a safe and effective remediation. Coordination will include obtaining access to areas north and east of the current fence line since impacted soils lie outside the facility fence.

All excavated soils and debris will be screened in the field for contamination, sampled, analyzed, and transported off-site for disposal if found to exceed the established cleanup criteria for the site. Following excavation, confirmation sampling and remediation compliance surveys will be conducted to ensure that approved remedial goals have been met. Due to the removal from the site of all material found to exceed the established cleanup criteria for the site, a post-remediation environmental monitoring program, and land-use or engineering controls will not be required after this alternative is implemented.

**HTRW REMEDIAL ACTION (CONSTRUCT) (WBS 331XX)**

**Mobilization and Preparatory Work (WBS 331XX01)**

This item includes the following activities:

- Mobilization of Construction Equipment and Facilities
- Submittals/Implementation Plans
- Setup/Construct Temporary Facilities
- Construct Temporary Utilities

Mobilization of Construction Equipment and Facilities - This activity includes the transport, initial assembly and setup of construction equipment prior to project startup. Work associated
with mobilization will include preparation of equipment for transport, equipment transportation and setup, drivers and equipment operators.

Submittals / Implementation Plans - This activity includes the work performed prior to, and during, remedial action for developing all necessary plans. The plans included are:

- Accident Prevention Plan (APP) / Site Safety and Health Plan (SSHP), to include a site specific Chronic Beryllium Disease Prevention Program (CBDPP)
- Contaminated Water Storage and Treatment Plan (Water Management Plan)
- General Site Work Plan (Backfill and Restoration Plan)
- Construction Quality Control Plan
- Material Handling / Transportation / Disposal Plan
- Emergency Plan
- Sampling and Analysis Plan, to include a site specific Air Monitoring Plan
- Site Operations Plan
- Radiation Protection Program
- Regulatory Compliance Plan
- Communications Plan
- Remediation Compliance Implementation Plan

Each of these plans will be prepared by competent project technical personnel and subject matter experts. A draft of each plan will undergo an internal independent technical review prior to submittal to the USACE. Responses to USACE (and other government agencies) review comments will be formulated and incorporated into the final plans. The estimated duration for preparation, review, revision and approval of required submittals is 12 months.

Setup / Construct Temporary Facilities - This activity includes procurement, setup, and construction of office trailers, storage areas, decontamination facilities, decontamination staging areas and other temporary facilities. The facilities included are:

- Office Trailers
- Storage Facilities
- Decontamination Facilities for Personnel
- Decontamination Facilities for Construction Equipment / Vehicles
- Lunch / Break Trailer (Craft Labor)
- Portable Toilets
- Government Trailer (USACE Office)
- Guard House
- Truck Scale
- Wastewater Treatment Plant
- Project Signs
- Erosion Control

Construct Temporary Utilities - This activity includes procurement and installation of a new down-hole water pump and skid mounted treatment system (ion exchange and granular activated carbon) in the existing East Production Well. Water from this well will be used for dust control and decontamination. Water from this well will not be used as potable.

The overall estimated duration for Mobilization and Preparatory Work (WBS 331XX01) is 16 months.

Monitoring, Sampling, Testing, and Analysis (WBS 331XX02)

This item includes the following activities:

- Meteorological Monitoring
- Radiation Monitoring
- Air Monitoring and Sampling
- Sampling Surface Water / Ground Water / Liquid Waste
- Sampling Soil and Sediment
- Sampling Radioactive Contaminated Media
- Laboratory Chemical Analysis
- Radioactive Waste Analysis
- Geotechnical Testing
- On-Site Laboratory Facilities
- Beryllium Monitoring, Sampling, Testing, and Analysis

Meteorological Monitoring - This activity includes the procurement, setup, testing, and operation of a meteorological station on the project site. These activities will be performed from site mobilization through completion of site demobilization.

Radiation Monitoring - This activity includes the following radiological control (RADCON) crews performing the indicated radiological monitoring activities:

<table>
<thead>
<tr>
<th>RADCON Crew</th>
<th>Monitoring Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>RADCON Crew - Year 1 Only</td>
<td>Establish Radiological Controls / Initial Baseline Surveys</td>
</tr>
<tr>
<td>RADCON Crew – Soil and Material Excavation</td>
<td>Radiological Monitoring – Excavation, Cutback Soils</td>
</tr>
<tr>
<td></td>
<td>Rad. Monitoring – Excavation, Subsurface Soils and Debris</td>
</tr>
<tr>
<td></td>
<td>Rad. Monitoring – Demolition, Production Building Slab</td>
</tr>
<tr>
<td></td>
<td>Rad. Monitoring – Demolition, Production Bldg. Annex</td>
</tr>
<tr>
<td>RADCON Crew – Soil and Material Characterization</td>
<td>Radiological Monitoring – Excavation, Cutback Soils</td>
</tr>
<tr>
<td></td>
<td>Rad. Monitoring – Excavation, Subsurface Soils and Debris</td>
</tr>
</tbody>
</table>
The composition of the RADCON Crews is as follows:

<table>
<thead>
<tr>
<th>RADCON Crew - Incoming / Outgoing</th>
<th>Radiological Monitoring - Outgoing Waste Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew</td>
<td>Radiological Monitoring - Incoming Temporary Facilities</td>
</tr>
<tr>
<td></td>
<td>Rad. Monitoring - Incoming Construction Equipment</td>
</tr>
<tr>
<td></td>
<td>Rad. Monitoring - Incoming Construction Materials</td>
</tr>
<tr>
<td></td>
<td>Radiological Monitoring - Outgoing Temporary Facilities</td>
</tr>
<tr>
<td></td>
<td>Rad. Monitoring - Outgoing Construction Equipment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RADCON Crew - Miscellaneous Routines</th>
<th>Wastewater Treatment Plant Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equipment and Temporary Facilities Decontamination</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RADCON Crew</th>
<th>Personnel</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1 Only</td>
<td>(1) Senior Radiation Tech, (5)</td>
<td>(1) Ludlum 2221, (1) Ludlum 2360, (1) Ludlum 19, (1) Ludlum 43-10-1,</td>
</tr>
<tr>
<td></td>
<td>Radiation Technicians, (1/2)</td>
<td>(1) Ludlum 44-10, (2) Ludlum 44-7, (1) Trimble GPS</td>
</tr>
<tr>
<td></td>
<td>Certified Health Physicist</td>
<td></td>
</tr>
<tr>
<td>Soil and Material Excavation</td>
<td>(1) Senior Radiation Tech, (1)</td>
<td>(1) Ludlum 2221, (1) Ludlum 177-61, (1) Bicron Micro Rem Meter, (2)</td>
</tr>
<tr>
<td></td>
<td>Radiation Technician, (1) Safety</td>
<td>(1) Ludlum 44-7, (1) Ludlum 44-20 3”x3” Nal Gamma Probe, (3) F&amp;J LV-1</td>
</tr>
<tr>
<td></td>
<td>and Health Technician</td>
<td>Low Volume</td>
</tr>
<tr>
<td>Soil and Material Characterization</td>
<td>(1) Senior Radiation Tech, (2)</td>
<td>(1) Ludlum 2221, (1) Ludlum 177-61, (1) Bicron Micro Rem Meter, (1)</td>
</tr>
<tr>
<td></td>
<td>Radiation Technicians</td>
<td>(1) Ludlum 44-7, (1) Ludlum 44-20 3”x3” Nal Gamma Probe, (1) Trimble GPS</td>
</tr>
<tr>
<td>Incoming / Outgoing</td>
<td>(2) Radiation Technicians</td>
<td>(2) Ludlum 2221, (1) Ludlum 177-61, (1) Ludlum 44-9 Pancake G-M</td>
</tr>
<tr>
<td>Miscellaneous Routines</td>
<td>(1/2) Senior Radiation Technician,</td>
<td>(2) Ludlum 2221, (1) B2/5 FIDLER Probe, (1) Ludlum 43-10, (2) Trimble GPS</td>
</tr>
<tr>
<td></td>
<td>(2) Radiation Technicians</td>
<td></td>
</tr>
</tbody>
</table>

In all instances were a RADCON crew is supporting another activity (e.g., excavation, material processing, loading, etc.) the duration of the RADCON crew activity is dependent on the duration of the activity being supported.

Air Monitoring and Sampling - This activity includes operation of seven (7) perimeter air monitors, one (1) off-site (background) air monitor, and three (3) area air monitors (active excavation / demolition location). Operation consists of retrieving the air filters, weekly counting for gross alpha / beta, and a monthly composite of the filters from each location for off-site laboratory analysis for Radium 226, 228, isotopic gamma via gamma spectroscopy, and isotopic Uranium via alpha spectroscopy. This activity also includes retrieving monthly composite air samples from the seven (7) perimeter air monitors, one (1) off-site (background)
air monitor, and three (3) area air monitors (active excavation / demolition location) for off-site analysis for gross alpha and gross beta. Filter media retrieved weekly from seven (7) perimeter air monitors, one (1) off-site air monitor, and three (3) area excavation / demolition air monitors will be sent to an off-site laboratory for analysis for Beryllium. These activities will begin at the start of Mobilization and Preparatory Work, and conclude at the completion of Demobilization.

Sampling Surface Water / Groundwater / Liquid Waste - This activity includes weekly sampling of one (1) surface water ditch for off-site chemical and radiological laboratory analysis. This activity also includes weekly sampling of precipitation, surface and groundwater collected from the waste excavation for off-site chemical and radiological laboratory analysis. These activities will begin at the start of Mobilization and Preparatory Work, and conclude at the completion of demobilization.

This activity also includes weekly retrieval of an estimated five (5) samples of Wastewater Treatment Plant (WWTP) effluent for off-site laboratory analysis. WWTP effluent sampling and analysis will begin concurrently with the start of excavation, and conclude at the completion of site restoration earthwork.

Sampling Soil and Sediment - This activity includes soil sample retrieval and shipping to the laboratory for the following soils:

- Off-site Unclassified Fill (excavation backfill) - Geotechnical classification, chemical and radiological analysis
- Off-Site Topsoil (site restoration) - Chemical and radiological analysis

In all instances the soil sampling activity is supporting a backfill / site restoration activity. The duration of the soil sampling activity is dependent on the duration of the associated backfill / site restoration activity.

Sampling Radioactive Contaminated Materials - This activity includes sampling the following surface soils:

- Cutback Soils – Chemical and radiological analysis
- Contaminated Soils - Chemical and radiological analysis
- Remediation Compliance Survey Areas – Chemical and radiological analysis

The duration of these sampling activities is dependent on the duration of the excavation and material sorting/sizing operations.

Sampling Radioactive Contaminated Materials also includes sampling the following demolition debris:
- Production Building Demolition Debris
- Production Building Slab Demolition Debris
- Production Building Annex Debris Piles
- Equipment Decon Pad Debris

These sampling activities will begin at the start of Production Building Demolition and conclude at the completion of the removal of the temporary facilities.

Laboratory Chemical Analysis - This activity includes laboratory chemical analysis the following:

- Cutback Soil
- Contaminated soils
- Remediation Compliance Survey Soils
- Production Building Demolition Debris
- Production Building Slab Demolition Debris
- Production Building Annex Debris Piles
- Equipment Decon Pad Debris
- Off-site Random Fill (excavation backfill)
- Off-site Topsoil (site restoration)
- Surface Water
- Liquid Waste
- Treatment Process Effluent

The duration of this analytical activity is dependent on the duration of the remedial action activities that the analytical activity is supporting.

Radioactive Waste Analysis - This activity includes the following:

- Monthly composite of the filters from each air monitoring location
- Surface Water
- Liquid Waste
- Treatment Process Effluent
- Off-site Unclassified Random Fill (excavation backfill)
- Off-site Topsoil (site restoration)
- Cutback Soil
- Contaminated Soils
- Production Building Demolition Debris
- Production Building Slab Demolition Debris
- Production Building Annex Debris Piles
- Equipment Decon Pad Debris
The duration of this analytical activity is dependent on the duration of the remedial action activities that the analytical activity is supporting.

Geotechnical Testing - This activity includes the following:

- Excavation Backfill - Geotechnical classification and compaction

The duration of this activity is dependent on the duration of the remedial action activities that the analytical activity is supporting.

On-Site Laboratory Facilities - This activity includes mobilization, rental, ownership, operation and demobilization of on-site radiological and chemical laboratories.

Beryllium Monitoring, Sampling, Testing and Analysis - This activity includes the following:

- Baseline Beryllium Inventory (10 CFR 850)
- Beryllium Hazard Assessment
- Beryllium Personnel Monitoring
- Beryllium Intermittent Surface Sampling and Analysis
- Beryllium Environmental (Perimeter) Monitoring
- Beryllium Sampling and Analysis - Construction Equipment

The overall estimated duration for Monitoring, Sampling, Testing and Analysis (WBS 331XX02) is 46 months.

Site Work (WBS 331XX03)

This item includes the following activities:

- Clearing and Grubbing - Approximately 5 acres
- Roads / Parking / Curbs / Walks – Install approx. 3,000 LF of temporary site haul roads
- Fencing – Install approximately 4,350 LF of site perimeter fence and gates

Site Work will begin at the conclusion of Mobilization and Preparatory Work, and will take three (3) months to complete.

Surface Water Collection and Control (WBS 331XX05)

This item includes weekly inspections of, and periodic repairs to, the sediment barriers / silt fences on the project site. The overall estimated duration for Surface Water Collection and Control (WBS 331XX05) is 46 months.
Solids Collection and Containment (WBS 331XX08)

This item includes the following activities related to cutback soils and contaminated soil and materials:

- Excavation
- Hauling (On-site Handling)

Excavation – It is assumed that a total of 109,974 BCY of soil and debris will be excavated. The assumed composition of this material is 6,082 BCY Cutback Soils, and 103,892 BCY of Subsurface Soils and Debris. Per the Feasibility Study, assumed excavation rate is 26 BCY/hr. The Excavation Crew consists of (2) Hydraulic Excavator 70,000 lbs, 2.0 CY bucket; (2) Equipment Operators, Heavy, (2) 4" Centrifugal Pump, (1) Equipment Operator, Medium and (2) Laborers.

This item also includes installation and removal of approximately 500 LF of steel sheetpile excavation shoring along the railroad berm in the northeast area of the project site.

The overall estimated duration for Solids Collection and Containment (WBS 331XX08) is 24 months.

Liquids / Sediments / Sludges Collection and Containment (WBS 331XX09)

This item includes start-up and performance testing of the Wastewater Treatment Plant. This item also includes operation of the Wastewater Treatment Plant from the start of excavation until the completion of site restoration earthwork. The overall estimated duration for Liquids / Sediments / Sludges Collection and Containment (WBS 331XX09) is 38 months.

Drums / Tanks / Structures / Miscellaneous Demolition and Removal (WBS 331XX10)

This item includes Demolition of the Production Building and the associated slab. Assume that main Production Building footprint is approximately 667' x 108' = 72,036 SF, and volume is approximately 3,241,620 CF. Assume that northern building projection footprint is approximately 66' x 53' = 3,498 SF, and volume is approximately 149,142 CF. Total approximate Production Building volume = 3,390,762 CF (Building dimensions and volumes provided by J. Hall, CELRB-TD-EE).

Cost Book Item 024116138120 - "Building demolition, multi-level building, concrete, includes 20 mile haul, excludes foundation demolition, dump fees" shows a production rate of 1,913 CF / hour. Given the site constraints, reduce that production rate by 50% to 957 CF / hour. This activity also includes loading building demolition debris into IMCs. The estimated duration for demolition of the Production Building and associate slab is 20 Months.
This item also includes removal of the existing debris piles from the prior demolition of the Production Building Annex. Assume that the Production Building Annex footprint is approximately 49' x 408' = 699,720 CF SF, and volume was approximately 3,241,620 CF. Applying a debris volume factor of 0.33 from "Debris Estimating Field Guide (FEMA 329 / Sept 2010)" results in an anticipated debris volume of 8,552 CY. Assuming that 25% of the debris volume was previously removed by the property owner results in an anticipated remaining debris volume of 6,414 CY. Assume that the Loading Crew consisting of one (1) 1.75 CY Front End Loader; (1) Equipment Operator, Heavy; and (2) Laborers can load the debris piles into IMCs at an average production rate of 10 CY/hour.

The estimated duration for removal of the existing debris piles from the prior demolition of the Production Building Annex is four (4) Months. It is assumed that removal of the debris piles will be concurrent with demolition of the Production Building.

**Disposal (Commercial) (WBS 331XX19)**

This item includes the following activities:

- Hauling / Unloading of Solids
- Disposal Fees and Taxes

Hauling / Unloading of Solids – Per the Feasibility Study, assume 1.3 Ton/LCY. Per the Feasibility Study Appendix 4B "Final Transportation Alternatives Assessment", Alternative "A", waste will be loaded into intermodal containers and transported via truck from the Site to an existing transfer station located approximately 10 miles (one-way) away. Here the intermodal containers will be loaded onto railcars and transported via rail to the final disposal location.

Disposal Fees and Taxes – Disposal Fees used in the cost estimate are from Contract No. W912DQ-10-D-3023. The disposal fees are as follows:

- LARW Soil $71.50 / Cubic Yard
- LARW Debris $71.50 / Cubic Yard
- LAWWW Soil $97.00 / Cubic Yard
- LAMW Debris $155.00 / Cubic Yard

The overall estimated duration for Disposal (Commercial) (WBS 331XX19) is 37 months.

**Site Restoration (WBS 331XX20)**

This item includes the following activities:

- Backfill
- Borrow
- Hauling
- Grading
- Compaction
- Topsoil
- Seeding / Mulch / Fertilizer

Backfill – Assume that 131,969 LCY of backfill will be dumped and spread in 6” layers. The assumed production rate for Backfill is 50 BCY/hour (65 LCY/hour) utilizing a crew consisting of one (1) Dozer, Crawler, 181-250 HP, and one (1) Equipment Operator.

Borrow – Assume that 109,974 LCY of off-site unclassified fill will be delivered to the project site and dumped at the waste excavations.

Grading – Assume that approximately 22.3 Acres of the project site will be rough graded. The assumed production rate for Grading is 0.0621 Acre/hour utilizing a crew consisting of one (1) Dozer, Crawler, 181-250 HP, and one (1) Equipment Operator.

Compaction – Assume that 109,974 ECY of backfill will be compacted at the waste excavations. The assumed production rate for Compaction is 50 ECY/hour utilizing a crew consisting of one (1) Roller, Vibratory, Double Drum, Padded Drum, one (1) Equipment Operator, Medium, and one-half (1/2) Laborer.

Topsoil – Assume that approximately 18,000 CY of off-site topsoil will be spread and graded at the project site. Topsoil production rates and crew composition vary depending on topsoil source and placement areas.

Seeding / Mulch / Fertilizer – Assume that 22.3 acres will be seeded and mulched at the project site.

The overall estimated duration for Site Restoration (WBS 331XX20) is 14 months.

Demobilization (331XX21)

This item includes the following activities:

- Removal of Temporary Facilities
- Final Decontamination
- Demobilization of Construction Equipment and Facilities
- Submittals
Removal of Temporary Facilities – This activity includes demobilization and dismantling of office trailers, storage and decontamination facilities, and other temporary facilities. The facilities included are:

- Office Trailers
- Storage Facilities
- Decontamination Facilities for Personnel
- Decontamination Facilities for Construction Equipment / Vehicles
- Lunch / Break Trailer (Craft Labor)
- Portable Toilets
- Government Trailer (USACE Office)
- Guard House
- Truck Scale
- Wastewater Treatment Plant
- Project Signs
- Erosion Control

Final Decontamination - Wastewater Treatment Plant equipment will be decontaminated as practical and pending acceptable post-decon analysis, will be free released from the site. Equipment that is impractical to satisfactorily decontaminate will be processed and disposed as LLRW debris. All construction equipment will be decontaminated until acceptable post-decon analysis for free release from the site is achieved.

Demobilization of Construction Equipment and Facilities - This activity includes the disassembly, takedown, and transport of construction equipment at the conclusion of project activities. Work associated with demobilization will include preparation of equipment for transport, equipment transportation, drivers and equipment operators.

Submittals – This activity includes preparation of a Construction Documentation Report which will include, at a minimum, all final reports, punch lists, project acceptance, final QA/QC reports and As-Built Drawings. The Construction Documentation Report, including the Remediation Compliance Survey Report and all Technical Data Packages, will be prepared by competent project technical personnel and subject matter experts. A draft of the report will undergo an internal independent technical review prior to submittal to the USACE. Responses to USACE (and other government agencies’) review comments will be formulated and incorporated into the final report. The estimated duration for preparation, review, revision and approval of required submittals is 6 months.

The overall estimated duration for Demobilization (WBS 331XX21) is 11 months.
General Requirements (331XX22)

This item includes the following activities:
- Supervision and Management
- Engineering, Surveying, and Quality Control
- First Aid, Fire Protection, and Traffic Control
- Health and Safety
- Temporary Construction Facilities – Ownership
- Temporary Construction Facilities – Operation
- Project Utilities

Supervision and Management – Assume the following personnel, and associated vehicles, travel and per diem:
- Program Manager (½ time, i.e. 88 hrs/mo., 2-day trip to site every 2 months)
- Project Manager (On-site full time, 1 trip home/month, per diem, vehicle)
- Site Superintendent (On-site full time, 1 trip home/month, per diem, vehicle)
- Clerk (On-site full time, local hire)

Engineering, Surveying, and Quality Control - Assume the following personnel, and associated vehicles, travel and per diem:
- Civil Engineer (On-site full time, local hire)
- Hydrogeologist (1/2 time, i.e. 88 hrs/mo., 2-day trip to site every 2 months)
- Scientist (Project Chemist) (On-site full time, local hire)
- Surveyors (On-site ¼ time, i.e., 44 hours/month; local hire/subcontractor)
- Cost Engineer/Scheduler (On-site full time, local hire)
- Waste Manager (On-site full time, local hire)
- Quality Control Manager (On-site full time, 1 trip home/mo., per diem, vehicle)
- Quality Control Engineer (On-site full time, local hire)
- Data Acquisition Manager (On-site full time, 1 trip home/mo., per diem, vehicle)

First Aid, Fire Protection, and Traffic Control - Assume the following personnel, and associated vehicles, travel and per diem:
- Water Truck w/ Driver (On-site full time, local hire)
- Watchman/Guard (Present at the site during non-working hours)

Health and Safety - Assume the following personnel, and associated vehicles, travel and per diem:
- Safety and Health Manager (CIH) (On-site full time, 1 trip home/month, per diem, vehicle)
- Radiation Safety Officer (CHP) (On-site full time, 1 trip home/mo., per diem, vehicle)
- Assistant Radiation Safety Officer (On-site full time, 1 trip home/mo., per diem, vehicle)
- Site Safety and Health Officer (On-site full time, 1 trip home/mo., per diem, vehicle)

Health and Safety also includes the following:

- Health and Safety Training - Includes 29 CFR 1926.65 HAZWOPER Training (40 hours plus 3 days of onsite training); DOE 10 CFR 835 Training (8 hours); Site-specific Safety Training (8 hours); Site-specific Beryllium Training (3 hours)
- Health and Safety Medical Exams – Includes Entry Physical, Annual Physical, Exit Physical, Beryllium Lymphocyte Proliferation (Be-LPT) Entry Testing, Be-LPT Re-test at 6 month intervals, Be-LPT Exit Testing
- Personal Protective Equipment (PPE) – Level D, Level C, Level B PPE as required by site conditions.
- Emergency Eye Wash, Body Wash and Shower – Assume six (6) stations located strategically around the project site.

Temporary Construction Facilities – Ownership – Assume monthly rental expenses for the following:

- Office Trailers and Facilities
- Storage Facilities
- Guard House
- Portable Toilets
- Decontamination Facilities for Personnel
- Lunch / Break Trailer (Craft Labor)
- Government Trailer (USACE Office)

Temporary Construction Facilities Operation – Assume the following monthly / annual operating expenses:

- Janitors and Cleaning Services – Clean office trailers on a weekly basis
- Annual Calibration of the Truck Scale

Project Utilities - Assume the following monthly project site utility expenses:

- Telephone
- Electricity
- Water (Potable)
- Internet
The overall estimated duration for General Requirements (WBS 331XX22) is 46 months.

**SUPERVISION and ADMINISTRATION (S&A) CONSTRUCTION MANAGEMENT (WBS 333XX)**

**USACE Labor and Contracts (WBS 331XX01)**

This item includes USACE labor and contracts for supervision, administration and construction management during the implementation of the remedial action, from start of Mobilization and Preparatory Work to completion of Demobilization. The estimated level of effort for this item was provided by CELRB-TD-EE. The overall estimated duration for Supervision and Administration (S&A) Construction Management (WBS 333XX) is 64 months.

**HTRW POST CONSTRUCTION AND FINANCIAL CLOSEOUT ACTIVITIES (WBS 34XXX)**

**FISCAL / FINANCIAL CLOSEOUT ACTIVITIES (WBS 341XX)**

**USACE Labor and Contracts (WBS 341XX01)**

This item includes USACE labor and contracts for post remedial action closeout activities. The estimated level of effort for this item was provided by CELRB-TD-EE. The overall estimated duration for Fiscal / Financial Closeout Activities (WBS 341XX) is 24 months.

**Contractor Assignment and Mark-ups**

Assume that a prime contractor will self-perform all work except radiation monitoring, radioactive waste analysis, on-site radiological laboratory, waste hauling and waste disposal. Assume that radiation monitoring, radioactive waste analysis, and on-site radiological laboratory will be performed by a Health Physics Subcontractor. Waste hauling and disposal will be performed by subcontractor(s) on a unit price ($/ton or CY) basis.

Assume that reasonable mark-ups for the Prime Contractor are: Home Office Overhead 15%, Profit 8%, and Bond 1.0%.

Assume that reasonable mark-ups for the Health Physics Subcontractor are: Home Office Overhead 15% and Profit 8%.

**Sales Tax**

A 6.5% Wood County, Ohio Sales Tax is applied to materials.
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Appendix C: Cost and Schedule Risk Analysis
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Appendix C – Cost and Schedule Risk Analysis

The Great Lakes and Ohio River Division of the United States Army Corps of Engineers (USACE) has completed remedial activities at five Formerly Utilized Sites Remedial Action Program (FUSRAP) sites. Due to the complexity of these sites, unforeseen difficulties sometimes resulted in significant cost increases and schedule impacts during remediation. Historically, the greatest unforeseen difficulty has been encountering contaminated areas not fully characterized during the remedial investigation. To improve USACE’s ability to accurately forecast project budget and schedule to remediate FUSRAP sites, the USACE, Buffalo District, developed a method of identifying, analyzing, and accounting for a wide range of risks that can affect a project’s cost and schedule.

USACE, Buffalo District, reached out to subject matter experts from USACE offices nationwide, including USACE contractors, to help develop a cost and schedule risk analysis (CSRA) process specific to USACE Great Lakes and Ohio River Division FUSRAP projects. Team members for this effort included experts from the following:

- USACE Headquarters.
- USACE Great Lakes and Ohio River Division.
- USACE Buffalo District.
- USACE Environmental and Munitions Center of Expertise, Omaha District.
- Argonne National Laboratory.

During the CSRA, estimated costs were developed for the selected remedy in the record of decision.

C1 Process

The CSRA process included four primary steps that allowed the project team to build on site-specific information and develop a complete understanding of potential cost and schedule risks and how to manage them. These steps began during the feasibility study, when the nature and extent of site contamination, and the human health and ecological risk associated with that contamination, were known.

Step 1: Estimate Contaminated Material Volume

The cost of cleaning up a contaminated site is primarily driven by the volume of FUSRAP-related contaminated material that requires remedial action. Estimating this volume accurately requires a thorough understanding of how the FUSRAP-related contaminants got to the site, where they are, and if they are migrating. As more is learned about the site during remedial action, the actual volume of FUSRAP-related contamination often exceeds the original volume estimate. This increases costs and causes schedule delays. With the help of Argonne National Laboratory, USACE used a geostatistical method (Bayesian Approaches for Adaptive Spatial Soil Sampling - BAASS), described in Appendix A, to estimate how much material is contaminated and will require remedial action. This estimating method provided a range of potential volumes and a percent confidence level associated with values in the range. The higher the confidence level associated with a certain contaminated soil volume, the more likely the actual volume found will be below the volume estimate. For the Luckey Site CSRA, the 50
percent, or risk-neutral, confidence level volume estimate was chosen for purposes of developing the base cost estimate.

**Step 2: Base Cost and Schedule Estimate**

The base cost estimate (provided in Appendix B) was developed using the second generation (MII) Micro-Computer Aided Cost Estimating System cost estimating software (version 4.2). This software is a detailed cost estimating application used by USACE for military; civil works; and hazardous, toxic, and radioactive waste projects.

**Step 3: Risk Register**

A project risk register was developed that presents, in tabular format, all known and suspected uncertainties related to cost and schedule for cleaning up the site. These are different than the human health and ecological risks that are addressed by the selected remedy documented in the record of decision and the explanation of significant differences. The risk register was compiled by the USACE project team. Each cost and schedule risk was discussed and assigned a likelihood of occurring and potential cost and schedule impact, which result in a qualitative risk level for each risk (high, moderate, or low). Current risk registers include 13 risk categories and between 60 and 90 individual cost and schedule risks. Each of these risks was evaluated to determine the probability of the project being affected by any one risk, and how much the project cost and schedule would be impacted. After input from the team was received, the risk register was subjected to a second team review to ensure that each cost and schedule risk was fully considered. The project uncertainty causing the greatest potential impact to cost and schedule was the increase in volume of FUSRAP-related contaminated material.

**Step 4: Cost and Schedule Risk Analysis**

The results of the first three steps served as a basis for a statistical analysis that incorporated all cost and schedule risks. The statistical evaluation determined how individual risks, and the combination of risks, can change the project cost and schedule. The risk analysis was applied to the base cost and schedule estimates, which resulted in a range of contingency costs. These contingency amounts were added to the base cost and schedule estimates and each were associated with a confidence level. The greater the confidence level, the higher the cost estimate and duration, and the less likely the actual cost and schedule duration will exceed the estimate. The Great Lakes and Ohio River Division has decided to use the 80 percent confidence level cost estimate for planning and budgeting of FUSRAP projects.

**C2 Cost and Schedule Contingency Results**

Cost contingency results for the 80 percent confidence level are identified below.

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