Remote Excavator Arm (REA) Move Analysis

300-296 Remote Soil Excavation Project

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

ch2m

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Richland, Washington 99352

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Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>REA</td>
<td>Remote Excavator Arm</td>
</tr>
<tr>
<td>ROM</td>
<td>Range of Motion</td>
</tr>
</tbody>
</table>
1.0 Purpose

The purpose of this document is to establish estimated durations required for the relocation of the Remote Excavator Arms (REAs) during soil removal operations.

2.0 Background

The 324 Building was completed in 1965 to support materials and chemical processing research and development activities at Hanford. Research operations at the facility ceased and stabilization cleanup activities began in 1996.

The 324 Building is being prepared for demolition, including stabilizing and preparing for the removal of the Radiochemical Engineering Complex (REC) cells. Contaminated grout was removed from the B-Cell sump and trench in support of demolition preparation. This grout removal revealed in November 2009 a visible breach in the stainless steel liner of the sump in the hot cell floor. Due to concerns about the possibility that B-Cell constituents had migrated through the breached liner, nonintrusive (closed-ended) characterization tubes were installed laterally into the soil column below B-Cell. Measurements inside the tubes confirmed the presence of radioactivity with gamma exposure rates up to approximately 13,000 R/hour. The peaks in the measured exposure rates approximately underlie the locations of the expansion joints in the B-Cell floor. It is believed that the leak from the B-Cell sump spread laterally along the felt liner between the floating B-Cell floor and the Cell foundation. Figure 1 provides a rough depiction of the distribution of contaminated materials.
The selected approach for soil removal is to access the contaminated soil by first removing the existing debris and grout, then the concrete floor and stainless steel liner of B-Cell. The contaminated soil will be removed using remotely operated equipment.

The Upper and Lower Remote Excavator Arms (REAs) (Figure 2) will be used to deploy the REA tools: Indeco® Breaker, CAT® Shear, PowerGrip® Bucket, Long Reach Bucket, PowerGrip I-Beam and REA Bin Lifting Tool. During soil removal activities, the REA system components within B-Cell will be relocated multiple times. The time required for REA relocation is driven by the design of the system, the operational sequence, and industrial health and safety and radiation control requirements. This study identifies the tasks and relocation durations associated with soil removal activities.

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1 INDECO is a registered trademark of Indeco Ind S.p.A., Viale Lindemann, 10, ZI; BARI, IT

2 CAT is a registered trademark of Caterpillar Inc., 100 N.E. Adams Street Peoria, IL

3 PowerGrip is a registered trademark of Helac Corporation, Enumclaw, WA
3.0 Scope

The scope of this document is to provide an estimate of time required to disconnect and relocate the upper and lower REAs between mounting locations. This will include consideration of REA tool (Figure 3) relocations within B-Cell for accessibility and the anticipated excavation process. This estimate will be used as a basis for activities in the project field execution schedule. This document will aid in refining initial time estimates for remote excavation of soil from the 300-296 waste site provided in PRC-SRP-00002, Rev. 0, 300-296 Soil Remediation Project Operations Assessment for Soil Retrieval.
Figure 3: REA Tools and Tool Holders

This document does not consider installation of the REA through supports or transport of the REAs and REA tools into B-Cell. Neither does this document consider failure recovery. An initial radiation materials evaluation (PRC-SRP-00009, 300-296 Soil Remediation Project Radiation Material Evaluation) indicates that hydraulic seals may exceed their maximum dose, based on an earlier estimated operating duration. The Radiation Material Evaluation report assumed the upper REA was installed in B-Cell and used to remove grout, equipment, and the cell floor for an exposure duration of 211 days. Then, the upper REA was assumed to be used for 575 days during remote soil excavation. These operating durations have been reduced in the project schedule and therefore, the hydraulic seals may not fail due to radiation exposure. For the purposes of this analysis it is assumed that the duration of activities in B-Cell has been reduced below the failure threshold.

4.0 Bases and Assumptions

Initial time estimates for remote excavation of soil have been developed and documented in PRC-SRP-00002. Additional discussions were held with members of the 300-296 Remote Soil Excavation Project team, 324 Building operations and radiological control technicians to develop the assumptions, tasks and estimated duration to complete each task for this study. Section 8.0 identifies the personnel who contributed to this study.
Soil removal operations may be separated into three unique phases: grout and debris removal, floor removal, and soil excavation. General assumptions and phase-specific assumptions are detailed below.

An install and move table (Table 1) was generated based on the four (4) REA installation locations. The B-Cell has been divided into four (4) quadrants: North West, North East, South West, and South East. These quadrants are illustrated in Figure 4.

![Figure 4: B-Cell Quadrant Definition](image)

### 4.1 General Assumptions:

1. The mechanical process of attaching and detaching the REAs is described in PRC-SRP-00025, R0, Final Design Report Narrative for the Remote Excavator Arm System.

2. The ‘picture frame’ soil excavation process will be as described in PRC-SRP-00030, R3, Operations Plan (300-296 Soil Remediation Project), with added detail in this analysis.

3. The REA System Hydraulic Power Units (HPUs) will not be relocated during REA movement. Four hydraulic power units will located in the gallery adjacent to each quadrant outside of B-Cell and are compatible with the upper and lower REAs.

4. Large equipment currently in B-Cell will be removed such that the upper REA may operate unimpeded (Figure 5).

5. Dummy posts will not be used after initial through support installation.

6. The B-Cell 3T crane will be used for relocating REAs and tool holders along the West wall.
7. REA tools will be stowed in tool holders (Figure 3) and hung on 4” Tool Hangers (Figure 6) strategically installed in the North, South and West walls (Figure 7).

8. Applying water to the exterior of soil bins to remove loose contamination and allowing the bin to dry through air-dry is not considered in this analysis.

9. Retrieving and returning tools such as the crane mounted camera or special lifting bail (Figure 8) is not considered in this analysis.

10. Removal and installation of the Transfer Mechanism is not considered in this analysis.

11. The number of upper and lower REA moves are estimated in PRC-SRP-00064, Rev. 0, Performance Specification 300-296 Soil Removal Project Remote Excavator Arm (REA) System, Appendix C, Table 4, and revised in this analysis.

12. This analysis assumes REA tools must be detached from the REA prior to relocating the REA. Time has been allowed for this operation during each tool change.

13. Four (4) tools may be stored in B-Cell without interfering with REA relocation. If there are greater than four (4) tools in B-Cell, tools will need to be strategically relocated when moving the REAs. Time to conduct these operations has not been accounted for in this document.

14. During excavations in close proximity to the North, South and West walls, the 4.5” tool hangers will be withdrawn into the wall to prevent interference with the REAs. Time to conduct these operations has not been accounted for in this document.

15. The REA excavation activities are not limited by the structural integrity of the facility. Structural modifications will be performed to mitigate undermining of the REC cells foundations during soil excavation.
Figure 5: Large Equipment and Debris in B-Cell

Figure 6: 4.5" Tool Hanger Details

Figure 7: Upper REA and Tools Suspended by 4.5" Tool Hangers
(Note: tool holders latest design not shown)
4.2 Grout and Debris Removal Assumptions

1. Only the upper REA will be used.

2. The upper REA does not have sufficient range of motion to reach all areas of the floor from one mounting location. It is assumed that it will need to be relocated three (3) times during grout and debris removal from B-Cell (Table 1).

3. Three (3) tools will be required in B-Cell during this phase:
   a. PowerGrip Bucket
   b. CAT Shear
   c. Indeco Breaker

4.3 Floor Removal

1. The upper and lower REA will be required for this phase. It is assumed that they will need to be relocated four (4) times during floor removal from B-Cell Table 1.)
2. Following grout and debris removal, the REAs will be left in the necessary locations to begin floor removal.

3. Three tools will be required in B-Cell during this phase:
   a. PowerGrip Bucket
   b. CAT Shear
   c. Indeco Breaker

4.4 Soil Removal Assumptions

1. The upper and lower REAs will be required for this phase. It is assumed that they will need to be relocated four (4) times during grout and debris removal from B-Cell (Table 1).

2. All five (5) tools will be required in B-Cell during this phase:
   a. REA bin lifting tool
   b. PowerGrip bucket
   c. CAT shear
   d. Indeco breaker
   e. Long reach bucket

3. Following floor removal, the REAs will be left in the necessary locations to begin soil excavation.

4. The upper REA must be installed in either the North East or South East through support mounting locations during the soil removal phase. These are the only locations in which it will be capable of placing waste bins in the Transfer Mechanism cart.

5. The soil excavation approach is:
   a. The REAs may excavate along perpendicular walls simultaneously or consecutively.
   b. The REAs will excavate as much contaminated soil as possible from each location before relocating to a new position.
   c. Move sequences have been optimized and conservative assumptions removed.
Table 1: REA Installation / Move Analysis Table

<table>
<thead>
<tr>
<th></th>
<th>Installs</th>
<th>Move 1</th>
<th>Move 2</th>
<th>Move 3</th>
<th>Move 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grout/Debris Removal</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Floor Removal (Assumed cutting is complete prior to install of Lower REA)</td>
<td>0</td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Soil Removal</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

It is assumed that soil removal will follow the ‘picture frame method’ as described in PRC-SRP-00030, *Operations Plan (300-296 Soil Remediation Project)*. Additionally, it is recommended that a ‘stepped’ excavation process be used rather than straight-wall trenching. This will minimize the risk of a non-recoverable cave-in damaging or trapping the REA. It will also allow for remote visibility when excavating under the footings. This process will involve separating low activity soil from high activity soil. Low activity soil will be relocated from the trench excavation zone to an adjacent area within the reach of the REA. Highly radioactive soil will be loaded out of B-Cell using waste bins. When the required excavation depth is achieved and verified by rad survey and sampling, the low level soil will be used to back-fill the trench. This method will involve systematically terracing the trench excavation to minimize soil collapse and sloughing (Figure 9, Figure 10). This is a deviation from the operations plan which currently states that the trench will be back-filled with grout. It is anticipated that additional testing, trials, evaluations or demonstrations will be conducted to verify this proposed excavation method.
Figure 9: Terraced Trench Excavation with Low Activity Soil Staging
Figure 10: Terraced Trench Excavation with Low Activity Soil Staging (top view)
5.0 Analysis

Analysis results were derived by assigning estimated durations to anticipated tasks required for REA relocation and applying these durations to the estimated number of relocations from Table 1. Multiple meetings were conducted over several weeks with participants from industrial health and safety, operations, engineering, and radcon. An effort was put forth to clearly understand the mechanical and process requirements associated with relocating an REA. Tasks discussed included: equipment bagging, mechanical attachment and detachment of the REAs, crane movements, and hydraulic hose connections. Resultant durations are shown in Table 2 and Table 3.
Table 2: Estimated Task Durations

<table>
<thead>
<tr>
<th>Action</th>
<th>Duration (hours)</th>
<th>Assumptions / Detail</th>
</tr>
</thead>
</table>
| Tool Attach/Remove      | 1                | a) B-Cell crane is available (not being used)  
                           | b) Attach and remove require same duration  
                           | c) Tool must be retrieved from 4" tool hanger and returned                                                                                                           |
| Equipment Relocation    | 2                | a) Baseline time requirements for moving the crane, engaging the hook, relocation and disengaging the crane from any piece of REA equipment within B-Cell                    |
| REA Couple/ Decouple    | 8                | a) Includes mechanical and control (hydraulic) coupling/decoupling actions in the 1st floor gallery (room 131)                                                               |

Table 3: Estimated REA Relocations

*(Table 4, Excerpted from PRC-SRP-00064, modified in this document)*

<table>
<thead>
<tr>
<th>Operation</th>
<th>Upper REA</th>
<th>Lower REA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grout Removal</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Floor Removal</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Soil Removal</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7</strong></td>
<td><strong>4</strong></td>
</tr>
</tbody>
</table>

Note: These values have been revised from PRC-SRP-00064 considering the divergence described in Section 4.4, Item 5.

6.0 Results

Given the assumptions provided in this document, the total estimated duration for relocations of the REAs is thirty one (31) shifts, assuming four (4) hours of work can be accomplished per shift within the REC, two (2) shifts per day and a seven (7) days per work week this would be a total duration of three (3) weeks. Details of the analysis are shown in in Appendix A. It should be noted that the previous version of this document (Revision 0) estimated a total duration of seven (7) weeks for these activities.

7.0 Conclusions

It is important to note that assumptions are made in this document and in SRP-00064 that significantly impact the number of tasks and the durations of tasks. This analysis used expert judgment to develop the durations for tasks to conduct relocation of an REA. The duration of each task could vary based on conditions within the 324 Building. This analysis and its contributors have bound the estimated durations to within reason without being overly conservative or optimistic.
8.0 \textbf{Contributors}

- April Wickersham – 324 Building Operations Manager
- Bill Gowey – 324 Radiological Control Supervisor
- Dewayne Smith – 324 Field Work Supervisor
- Kelly Ellis – 324 Facilities Radiological Engineer
- Steve Marske – Technical Integration
- Pat Jenkins – 324 Shift/Maintenance Manager
- Lori Dombrowski – Project Industrial Hygienist
- Eric Ison – Engineering Manager
- Will Picket – Project Operations Manager
- Michael Flannery – Field Manager
- John Winkler – Project Operations Manager

9.0 \textbf{References}

PRC-SRP-00002 Rev. 0, \textit{300-296 Soil Remediation Project Operations Assessment for Soil Retrieval}, CH2M HILL Plateau Remediation Company, Richland WA


### Appendix A

#### Analysis Results Table

<table>
<thead>
<tr>
<th>Action</th>
<th>Qty</th>
<th>Duration (hrs) / Ea</th>
<th>Duration Subtotal (hrs)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grout &amp; Debris Removal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper REA Relocations</td>
<td>3</td>
<td>11</td>
<td>33</td>
<td>a) Less 1 relocation from PRC-SRP-00064 due to disregarding installation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b) Duration = Equipment Relocation + REA Couple / Decouple + Tool Attach / Detach</td>
</tr>
<tr>
<td>Tool Relocations</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>a) Assuming Breaker, PowerGrip and Shear may be hung on second floor and not interfere with REA operations or relocation</td>
</tr>
<tr>
<td><strong>Floor Removal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper REA Relocations</td>
<td>3</td>
<td>11</td>
<td>33</td>
<td>a) Assuming Breaker, PowerGrip and Shear may be hung on second floor and not interfere with REA operations or relocation</td>
</tr>
<tr>
<td>Lower REA Relocations</td>
<td>1</td>
<td>11</td>
<td>11</td>
<td>a) Less 1 relocation from PRC-SRP-00064 due to disregarding installation</td>
</tr>
<tr>
<td>Tool Relocations</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>a) Assuming Breaker, PowerGrip and Shear must be used.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b) Tools may be hung on second floor and not interfere with REA operations or relocation</td>
</tr>
<tr>
<td><strong>Soil Removal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper REA Relocations</td>
<td>1</td>
<td>11</td>
<td>11</td>
<td>Less 1 relocation from PRC-SRP-00064 due to assuming no REA replacement</td>
</tr>
<tr>
<td>Lower REA Relocations</td>
<td>3</td>
<td>11</td>
<td>33</td>
<td>Less 1 relocation from PRC-SRP-00064 due to assuming no REA replacement</td>
</tr>
<tr>
<td>Tool Relocations</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>a) Assuming Breaker, PowerGrip, Shear, REA Bin Lifting Tool and Long Reach Bucket will be used</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b) Assuming 4 tools may be hung up high and not interfere with relocation or operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>c) One tool must be relocated each time the REA is moved between the North and South walls</td>
</tr>
<tr>
<td>Total Relocation Duration</td>
<td></td>
<td></td>
<td>121</td>
<td></td>
</tr>
<tr>
<td>Total Shifts</td>
<td>31</td>
<td></td>
<td></td>
<td>a) Assuming 4 hours per shift</td>
</tr>
<tr>
<td>Total Days</td>
<td>16</td>
<td></td>
<td></td>
<td>a) Assuming 2 shifts per day</td>
</tr>
<tr>
<td><strong>Total Weeks</strong></td>
<td></td>
<td></td>
<td></td>
<td>a) Assuming 7 day work week</td>
</tr>
</tbody>
</table>