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FLUOR FERNALD
SILOS PROJECT

Silo 3 Retrieval and Disposition Nuclear Health and Safety Plan

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Silo 3 Retrieval and Disposition Nuclear Health and Safety Plan

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RECORD OF ISSUE/REVISION

NOTE: The main body of the Silo 3 N-HASP (prepared by Fluor Fernald staff) determines the operable effective date for the entire N-HASP package. The appendices provided by Jacobs Engineering are stand-alone components with their own revision numbers. Outside the annual revision process, a change in an appendix does not increase the revision number for the entire document; it is considered an N-HASP PCN.

EFFECTIVE DATE	PCN NO.	REV. NO.	DESCRIPTION
02-09-04		0	Initial issue of N-HASP to identify hazards, controls, and mitigators for Silo 3 retrieval and disposition.
03-19-04	1	0	PCN for: (1) Section 1.2, *FCP Site History and Description*, to specify Silo 4 demolition; (2) Section 1.4, *Silo 3 Process Description*, to specify Silo 4 demolition and to clarify training plans for Silo 3 penetration; (3) Figure 1-1 to add charge tanks and specify shipping mode; (4) Section 6.0, *Management of Change*, to clarify when the Silo 3 Safety Basis Impact Screen (SBIS) is used, and to address the management of software change; (5) Table 8-23, *Radiological Hazard Controls*: *Radiological Access Controls: Access to Controlled Areas*, to specify the location of the Silo 3 control point and TLD storage, and to require workers not receiving TLDs to report to Silo 3 Rad Con for time-tracking while in the Controlled Areas; (6) Section 10.2, *Silo 3 System Safety Requirements*, to PR-1 to clarify Silo 3 stack monitoring; to PR-3 to specify that IP-2 bulk bags/packages must be sealed before transfer outside of the Cargo Bay area; to PR-5 to remove operations procedures from the Implementation column; (7) Section 20, *References*, to update two references; (8) Appendix B to update two references; (9) Appendix C to clarify responsibilities for evaluating and revising manuals and procedures.
05-21-04	2	0	PCN for: (1) Section 1.3.3, *Silo 3 History*, to note Silo 3 N-HASP approval; (2) Section 1.4.3, *Silo 3 Material Retrieval and Packaging Activities*, to clarify the process for dealing with an overfilled bag; (3) Section 1.4.4, *Retrieval Operations Personnel*, to make the operations estimate consistent with a similar statement in App. F; (4) Section 1.5.1, *Lessons Learned from WPRAP Applicable to Silo 3*, to add a lesson regarding respirator issuance; (5) Section 1.6, *Silo 3 Project*

EFFECTIVE DATE	PCN NO.	REV. NO.	DESCRIPTION
05-21-04 (cont.)	2	0	*Organization*, to update SH&Q division name, and to clarify that the Silos Quality Manager is responsible to the Fluor Fernald QC Project Operations Manager as well as to the Silos SPD; (6) Section 4.0, *Conduct of Operations*, to specify that RM-0029 describes the applicability of DOE O 5480.19 at the FCP; (7) Section 8.8, *Elevated Work Hazard Controls*, to remove reference to SPR-2-16; (8) Section 8.19, *Heat and Cold Stress Hazards*, to remove cool vests and cold-weather gear from Table 8-19; (9) Section 8.20, *Heavy Equipment Hazards*, to remove reference to SPR 7-3; (10) Section 8.21, *Radiological Hazards*, to clarify Fluor Fernald Line Management responsibility for ensuring the radiological protection of workers and the environment, to clarify that Silo 3 workers will be monitored for external whole-body gamma exposure, and to be more specific on expected dose rates for the Cargo Bay area in Table 8-21; (11) Section 8.22, *Chemical Hazards*, to add eye contact and ingestion to the list of general occupational hazards, and to update the technical information for sodium lignosulfonate and ferrous sulfate based on new information; (12) Section 12.0, *Personal Protective Equipment*, to make Note 1 for Table 12-1 plural (contaminants); (13) Section 14.0, *Monitoring*, to clarify that the Action Level for the Combustible Gas Indicator (CGI) is $\geq$ 10% of the LEL (Lower Explosive Limit); (14) Section 16.0, *Emergency Response Plan*, to change an item in *What to Report* from "Unusual Occurrences" to "Atypical Events," to update emergency response information to reflect the new contract with Crosby Township, to clarify the location of the back-up assembly area (since the west water tower is now gone), and to state that personnel will assemble in the Excavator Room during severe weather; (15) Section 17.0, *Occurrence Reporting*, to update the reference data for the DOE ORPS order and associated manual, and to add a description of PAAA and its implementation at Fluor Fernald; (16) Volume 1 to make incidental corrections; (17) App. A, *Executive Summary*, to add "Breach of DOT package in ISA" to bullet list of analyzed hazards; (18) Section C-2.1.1, *Pneumatic Retrieval*, to clarify operation of the high-level alarm; (19) App. C, Att. 1, Item F.1, *Workload and Stress Factors*, to change Col. 3 from Yes to No (i.e., the control room is <u>not</u> always occupied); (20) App. C, Att. 2, HVAC System, to clarify location; (21) App. F, to clarify the respective fire response services to be provided by FCP and the Subcontracted Emergency Response (Crosby Township),

EFFECTIVE DATE	PCN NO.	REV. NO.	DESCRIPTION
05-21-04 (cont.)	2	0	and to change future tense to present tense (due to the implementation of plans); (22) App. F, *Executive Summary,* and F-5.2, *Fire Suppression,* to explain why Silo 3 hose runs over 300 ft. are acceptable under DOE-STD-1066-99; (23) App. F, *Executive Summary,* and Section F-1.0, *Introduction*, to clarify when the FHA may need updating; (24) Section F-1.2, *Approach and Assumptions*, to delete erroneous information about the Electrical Building; (25) Section F-2.1, *Type of Construction*, to specify that the Electrical Building is insulated; (26) Section F-2.2, *Fire Barrier Separation*, to specify why the vestibule is not required to have a 1-hour rating; (27) Section F-3.2, *Means of Egress*, to clarify the extent of handicap accessibility; (28) Section F-5.2, *Fire Suppression*, to add a reference for the DOE memo that provided a fire suppression system exemption, and to delete the statement that the ventilation system will be used to reduce the oxygen supply of a fire; (29) Section F-5.3, *Smoke Detection System*, to specify that smoke detectors are 24V; (30) Section F-6.5, *Emergency Planning*, to specify the documents involved in the integration of Silo 3 emergency planning with site emergency planning; (31) Section F-7.0, *Conclusion*, to delete clause that the ventilation system will be used to reduce the oxygen supply of a fire; (32) Section G-2.1, *Basic Calculation Method for Solids Release*, to change text discussing continuous release receptor distance from 330m to 350m (calc is correct); (33) Section G-3.2, *EBA-2: Silo Wall Containment Failure*, to clarify sentence subjects (Parsons calc vs. FCP calc); (34) Section H-5.2, *Administrative Controls*, and Section H-6.2, *Area Air Monitoring*, to specify (and add reference for) the Air Sampling Plan for Silo 3 Operations.

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ACRONYMS

AC: Alternating current
ACGIH: American Conference of Governmental Industrial Hygienists
AEDO: Assistant Emergency Duty Officer
ALARA: As Low As Reasonably Achievable
ANSI: American National Standards Institute
APR: Air Purifying Respirator
ASR: Auditable Safety Record
AWR: Advanced Waste Retrieval
BIO: Basis for Interim Operations
CAM: Continuous Air Monitor
CDL: Commercial Driver's License
CFR: Code of Federal Regulations
CGI: Combustible Gas Indicator
CM: Configuration Management functional area
CM: Construction Manager
CM^2: Square centimeters
COC: Constituent of concern
CONOPS: Conduct of Operations
CPC: Constituents of Potential Concern
D&D: Decommissioning and Deactivation
DAC: Derived Air Concentration
dBA: decibel
DC: Direct current
DCN: Design Change Notice
DOE: U. S. Department of Energy
DOT: Department of Transportation
dpm: disintegrations per minute
DSA: Documented Safety Analysis
EBA: Evaluation Basis Accident
ECL: Effective Concentration Limit
ED: Engineering Design functional area
EIP: Energy Isolation Plan
EMS: Emergency Message System
EMT: Emergency Medical Technician
EPA: Environmental Protection Agency
ERT: Emergency Response Team
ES&H: Environment, Safety, and Health
FAT&LC: Fernald Atomic Trades and Labor Council
FCP: Fernald Closure Project
FEMP: Fernald Environmental Management Project
FHA: Fire Hazard Analysis
FMPC: Feed Materials Production Center
GFCI: Ground Fault Circuit Interrupter
HAR: Hazard Analysis Report
HASP: Health and Safety Plan
HAZWOPER: Hazardous Waste Operations and Emergency Response
HC: Hazard Category
HCC: Hazard Category Calculation
HCC: Hazardous Chemical Classification
HEPA: High Efficiency Particulate Air (filter)
HFE: Human Factors Evaluation
HFM: Hand and Foot Monitor
HPP: Health Physics Plan
HVAC: High Volume Air Conditioning
IES: Illuminating Engineering Society of North America
IHA: Integrated Hazard Analysis
IP-2: Industrial Package Type 2
ISA: Interim Staging Area
ISM: Integrated Safety Management
K-65: Silos 1 and 2
lb/ft^3: Pounds per cubic foot
LEL: Lower Explosive Limit
LLRW: Low-level radioactive waste
mg/Kg: Milligrams per kilogram
MIP: Maintenance Implementation Plan
MRS: Mechanical Retrieval System
MSDS: Material Safety Data Sheet
N-HASP: Nuclear Health and Safety Plan
N&SS: Nuclear and System Safety functional area
NIOSH: National Institute for Occupational Safety and Health
NTS: Nevada Test Site
O&M: Operations and Maintenance
ORPS: Occurrence Reporting Processing System
ORT: Occurrence Reporting Team
OSHA: Occupational Safety and Health Administration
OU-4: Operable Unit 4 (Silos area)
PAPR: Powered Air Purifying Respirator
PAT: Proficiency Analytical Test (program)
pCi/L: Picocuries per liter
PCM: Personal Contamination Monitor
PEL-TWA: Permissible Exposure Level/Time-Weighted Average
PHAR; Preliminary Hazard Analysis Report
PID: Photo Ionization Detector
PLC: Programmable Logic Control
PM: Project Manager
PPE: Personal Protective Equipment
PRI: Potentially-releasable inventory
ppm: Parts per million
PR: Process Requirement
PRS: Pneumatic Retrieval System
PVC: Poly-vinyl chloride
PWID: Project Waste Identification and Disposition (report)
QA: Quality Assurance
QAJSP: Quality Assurance Job-Specific Plan
QAP: Quality Assurance Program
QC: Quality Control
RAD: Radiological (facility)
RCT: Radiological Control Technician
RQ: Reportable Quantities
RWP: Radiation Work Permit

ACRONYMS

S&H: Safety and Health (department)
SAR: Safety Analysis Report
SBD: Safety Basis Documentation
SBDR: Safety Basis Documentation Review
SBIS: Safety Basis Impact Screen
SBR: Safety Basis Requirement
SCBA: Self Contained Breathing Apparatus
SE: Safety Evaluation
SER: Safety Evaluation Report
SH&Q: Safety, Health, and Quality (division)
SMSD: Safety Management System Description
SOP: Standard Operating Procedure
SPR: Safety Performance Requirement
SRC: Safety Review Committee
SSA: System Safety Analyst
SSC: Systems, Structures, and Components
SSR: Standard Startup Review
STD: Standard
SWRS: Silos Waste Retrieval System
TCLP: Toxicity Characteristic Leaching Procedure
TLD: Thermoluminescent dosimeter TLV-TWA: Threshold Limit Value/ Time-Weighted Average
TPQ: Threshold Planning Quantity
TQP: Training and Qualification Program
TSR: Technical Safety Requirement
TWA: Time-weighted average
UL: Underwriter's Laboratory
ULPA (ultra-low penetrating air) filter
USQ: Unreviewed Safety Question
USQD/SE: Unreviewed Safety Question Determination /Safety Evaluation
VitPP: Vitrification Pilot Plant
VOC: Volatile organic compound
VWMS: Vacuum Wand Management System
WPRAP: Waste Pits Remedial Action Project
WSA: Waste Storage Area

1.0 INTRODUCTION

1.1 Purpose and Scope

This Silos project-specific Nuclear Health and Safety Plan (N-HASP) was developed to ensure that hazards have been identified and that controls or mitigators will be in place to support the safe operation of Silo 3 retrieval and disposition process. The Silo 3 N-HASP is being submitted to satisfy a commitment in the U.S. Department of Energy (DOE)-approved *Decision Basis Document Implementation of 10 CFR 830 Safe Harbor Requirements for the Silos Projects,* 40000-RP-0034 [Ref. 1]. This N-HASP meets the requirements of Title 10 Code of Federal Regulations (CFR) 830.204, *Documented Safety Analysis* (DSA) [Ref. 2]; 29 CFR 1910.120 (b)(4), *Site Specific Health and Safety Plan* [Ref. 3]; and follows the general rules for HASP development as outlined in NS-0005, *Initiating, Reviewing, and Approving DOE-Approved SBDs* [Ref. 4].

The Silo 3 Retrieval and Disposition Project has been determined to qualify as a Radiological (RAD) Facility based on the analyses discussed in Appendix B, *Hazard Category Calculation*. Although Silo 3 inventory qualifies as nuclear Hazard Category 3 (HC-3). The retrieval and disposition activities and facilities qualify as RAD based on analytical consequences. Per DOE-STD-1120-98, *Integration of Environment, Safety and Health into Facility Disposition Activities* [Ref. 5], a RAD categorization/classification based on analytical consequences requires DOE approval. A more detailed discussion of the safety basis is provided in Section 5.0. Silo 3 System Safety Requirements are listed in Section 10.0.

This N-HASP is divided into two volumes. Volume One contains the standard requirements of a 29 CFR 1910.120 HASP, into which have been inserted sections addressing the Silo 3 System Safety Requirements and the Work Control Processes related to the Silo 3 process. Volume Two includes the analyses that support the Silo 3 DOE decision basis [i.e., Integrated Hazard Analysis (IHA), Hazard Category Calculations (HCC), Human Factors Evaluation (HFE), ALARA (As Low As Reasonably Achievable) Analysis, Environmental ALARA Analysis, Fire Hazards Analysis (FHA), Accident Analysis, and Health Physics Plan (HPP)]. These analyses were used to develop the Silo 3 System Safety Requirements that provide defense-in-depth. Together, Volumes One and Two comprise a DSA that meets the requirements of 10 CFR 830.204, *Nuclear Safety Management* [Ref. 6].

1.2 FCP Site History and Description

From 1952 until 1989, the Fernald site provided high-purity uranium metal products to support U.S. defense programs. Note: From 1952 until 1992, the site was called the Feed Materials Production Center (FMPC). Starting in 1992, the site was called the Fernald Environmental Management Project (FEMP). Recently, the site name was changed to the Fernald Closure Project (FCP). The FCP is operated by Fluor Fernald, Inc. (previously called Fluor Daniel Fernald, Inc.)

Uranium production halted in 1989 because of declining demand and a recognized need to commit available resources to environmental remediation. Former uranium operations at the FMPC site were limited to a fenced 136-acre tract near the center of the site known as the (former) Production Area. Large quantities of liquid and solid wastes were generated by the various FMPC production operations. Before 1984, solid and slurried wastes from FMPC processes were stored or disposed of in the Waste Storage Area (WSA). This area, located west of the production facilities, includes: six low-level radioactive waste (LLRW) storage pits; two concrete silos with earthen berms containing K-65 residues; one concrete silo containing metal oxides; one unused concrete silo; two lime-sludge ponds; a burn pit; a clearwell; and a solid-waste landfill. The WSA is part of Operable Units 1, 2, and 4. The former Production Area and WSA are fenced and closed to the general public. The remaining 914 acres of the site consist of forest, fields, wetlands, and pasture lands.

Operable Unit 4 (OU4) is a 5.8-acre area located on the western side of the site containing the following FCP facilities and associated environmental media:

- Silos 1 and 2 and their contents (also called K-65 Silos)
- Silo 3 and its contents (also called Cold Metal Oxide Silo)
- Silo 4 (formerly empty; now demolished)
- The decant sump (an underground tank and its contents)
- A portion of a concrete pipe trench and other concrete structures (currently being decommissioned)
- An earthen berm surrounding Silos 1 and 2
- Soils beneath and immediately surrounding the silos
- Perched groundwater in the vicinity of the silos
- Remainder of the Vitrification Pilot Plant (now known as the Silos Operations & Maintenance [SOM] building) and associated operations pad
- Associated abandoned underground utilities and foundations

Silo 3 was constructed for the transfer and storage of "cold" 11e.(2) uranium processing byproduct material [as designated by the Atomic Energy Act (AEA) of 1954, as amended] generated through refinery operations at the FMPC site. The Silo 3 material is a by-product of uranium-bearing ore concentrate processing. The ore concentrates had been preprocessed through a uranium mill where a significant portion of the Ra^{226} and the gamma-emitting progeny were removed, and thus they were termed "cold" feed material. Silo 3 received metal oxide raffinates generated by all FMPC refinery operations from May 1954 until late 1957.

1.3 Silo 3 Structure, Contents, and History

1.3.1 Silo 3 Structure

Silo 3 was constructed in 1952 and is located south of the Waste Pit Area of the FCP property. Silo 3 is a free-standing, post-tensioned concrete, domed silo. It is approximately 80 feet in diameter and approximately 33 feet above ground level (apex). The floor system is approximately 17 inches of compacted clay, a 2-inch thick layer of asphaltic concrete, and an 8-inch layer of gravel, topped by 4 inches of concrete. Silo 3 does not have an underdrain system. The domed

roof tapers from 8 inches thick at the silo walls to 4 inches thick at the apex. The apex is 36 feet high from top of foundation, 33 feet above grade. The walls are 27 feet high from the top of the foundation. Silo 3 contains increased reinforcing around the dome periphery (ring beam) to support the additional loading from a dust collector that has since been removed. Silo 3 has wire-wrapped post-tensioning using 8-gauge wire drawn to 0.141 inches. Silo 3 has 46 decant ports, each with a weir and baffle system. There are 23 decant ports on the east side wall and 23 on the west side wall.

The Silo 3 pneumatic retrieval process will make use of existing dome manways. Five manways have an internal diameter of approximately 20 inches. One manway, on which a dust collector was installed, is centered on the silo dome. Four of the manways, which were used as material inlet ports, are arranged radially, about 25 feet from the center manway and 90 degrees apart. There are two additional 24-inch internal diameter manways, one at the northern dome edge and one at the eastern dome edge. The dome also has 24 two-inch diameter sounding pipes and one 6-inch diameter vent pipe.

1.3.2 Silo 3 Contents

Silo 3 contains "cold" metal oxide waste generated from the operation of the former Feed Materials Production Center (FMPC), now known as the Fernald Closure Project (FCP). The raffinates from the solvent extraction process were de-watered using rotary vacuum filters. The filtrate wastes were then processed through evaporators, and the concentrates were further processed using either a spray calciner or rotary calciner. From plant start-up through the middle 1950s, a spray calciner processed the concentrates. Approximately 35% of the Silo 3 material is believed to have come from this process. Due to operational difficulties with the spray calciners, a rotary calciner process was implemented. In this process, the evaporator concentrates were transferred to a drum dryer and finally a rotary calciner. The calciner removed residual liquids and converted the metal nitrates to metal oxides.

The resultant fine, powdered metal oxides were transferred to Silo 3 pneumatically. Placement of these metal oxide wastes into Silo 3 began in 1954 and continued until 1957. After that, refinery process wastes were placed in on-site surface impoundments.

The Remedial Investigation conducted for Silo 3 [Ref. 7] reveals that the silo contains an estimated 5,088 yd^3 of residue. The predominant radionuclide of concern identified within the material is thorium-230, a radionuclide produced from the natural decay of Uranium-238. Based on an estimated in situ material density ranging from 29 to 58 pounds per cubic foot (lb/ft^3), the available silo material weighs, at most, approximately 3,930 tons. The physical composition of the Silo 3 waste, based on process knowledge and visual observations, is:

- potentially dry, loose, or fine powder at the top
- compacted powder towards the central and lower portions
- potentially water-saturated powder at bottom (approximately 1 ft).

A detailed description of Silo 3 waste material inventory is provided in Appendix B, Section B-2.0.

1.3.3 Silo 3 History

1952: Silo 3 constructed.

1954-1957: Silo 3 received "cold" metal oxide waste materials.

1991: Removal Action [Ref. 8] initiated to ensure that all penetrations through the dome were covered and sealed. Removal of the dust collector and permanent sealing of all obvious open pathways completed January 8, 1992.

1994: *Proposed Plan for Remedial Action at Operable Unit 4* [Ref. 9] prepared by FEMP, reviewed by DOE, and approved by USEPA and OEPA. This entailed retrieval of the Silo 3 material, on-site vitrification of the material, and off-site disposal of the vitrified material.

Final Record of Decision for Remedial Actions at Operable Unit 4 [Ref. 10] prepared by FEMP, reviewed by DOE, and approved by USEPA and OEPA.

FEMP-2337, *Preliminary Safety Analysis Report* [PSAR] *for Operable Unit 4* [Silos 1-4] [Ref. 11], was prepared. Silo 3 was assigned a final hazard category of HC-3 based on the associated hazard analysis.

1998: Due to difficulties encountered with the vitrification process during equipment performance trials, alternate treatment processes were identified and investigated for Silo 3 remediation. A *Final Explanation of Significant Differences for Operable Unit 4 Silo 3 Remedial Action* [Ref. 12], that entailed an alternate treatment plan, was approved. The alternate treatment plan was defined as treatment to meet the Toxicity Characteristic Leaching Procedure (TCLP), disposal at a permitted commercial disposal facility, and of-site treatment using either chemical stabilization/solidification or a polymer-based encapsulation process.

Fluor Daniel Fernald prepared a *Hazard Analysis Report (HAR) for Operable Unit 4 Silos*, [Ref. 13]. Based on a comparison of radioactive material quantities to the threshold limits in DOE STD1027-92, hazard categorization for the OU4 Silos was determined to be HC-3.

Fluor Daniel Fernald awarded a contract to Rocky Mountain Remediation Services (RMRS) to design, construct, and perform Silo 3 remediation, including performance of the associated safety analysis and preparation of safety basis documentation.

1999-2000: RMRS conceptual and preliminary design developed. This entailed pneumatic retrieval of the Silo 3 material, chemical stabilization of RCRA metals and solidification into bricks, and off-site disposal. The treatment facility contained a large storage bin because the treatment process philosophy called for continuous mixing and treatment, requiring a large inventory of retrieved material.

2000: RMRS prepared a Preliminary Hazard Analysis Report (PHAR) for Silo 3 [Ref. 14], which assigned HC-3 to Silo 3 and the associated retrieval and treatment systems. This assignment was based on the proposed RMRS design, inventory of radioactive materials,

and safety analyses. Segmentation was not used. The bounding accident consequence from analyzed scenarios resulted from a silo failure that released and dispersed up to one percent of the total Silo 3 inventory. Analyzed initiating events included natural phenomenon hazards (e.g., earthquake or tornado) and man-made hazards (e.g., crane failure or truck impact). No safety significant structures, systems or components were identified. As a result, a performance category or PG-2 was assigned to the facility, requiring design and construction per uniform building codes. Only limited damage from design basis natural phenomena hazards is expected.

Silo 3 PHAR approved by DOE for procurement and construction.

2001: Contract with RMRS terminated by mutual agreement.

Fluor Fernald prepared the *Silo 3 Project Rescoping Evaluation and Recommendation*, 40400-RP-0007 [Ref. 15]. This report recommended mechanical retrieval (excavation) of Silo 3 material, on-site chemical stabilization treatment, packaging into soft-sided containers, and rail shipment of the material to a permitted commercial off-site disposal facility.

Fluor Fernald re-evaluated the calculations supporting the RMRS Silo 3 PHAR. This review showed that highly-conservative assumptions were used to predict consequences, thus bringing into question the justifiability of the final HC. For example, a point-source release was assumed, giving no credit to the large surface area occupied by the spilled material following a silo failure. In addition, dose-conversion factors for certain radionuclides were over-estimated based on assumptions of solubility class. Consequently, Fluor Fernald re-evaluated the HC calculation for the bounding accident identified in the PHAR (silo failure due to earthquake).

Fluor Fernald issued the *Operable Unit 4 (OU4) Silo 3 Project Auditable Safety Record*, SA-2001-1026 [Ref. 16], which classified Silo 3 and its associated remediation systems and facilities as Radiological (RAD). The ASR included a Silo 3 earthquake evaluation calculation, SA-CALC-052 [Ref. 17], that presented a potential localized radiological dose consequence below the HC-3 dose threshold. The ASR transmittal to DOE included a recommendation that limited procurement, construction, and system operability testing continue without additional preliminary documented safety analysis. Design changes, new activities, maintenance alterations, and changed/new operating procedures were screened via the Silos Project Safety Basis Impact Screen (SBIS) (see Section 6.0).

DOE reviewed ASR SA-2001-1026 and concurred with Fluor Fernald's recommendation on continuing limited procurement, construction, and system operability testing without additional preliminary documented safety analysis. However, DOE did not concur with classifying both Silo 3 and its remediation systems and facilities as Radiological (RAD). Instead, DOE requested that Fluor Fernald comply with 10 CFR 830 [Ref. 2] in the development of the Silo 3 documented safety analysis.

Fluor Fernald withdrew the ASR request to reclassify Silo 3 and its remediation facilities from HC-3 to RAD in favor of an alternative approach based on 10 CFR 830. The

alternative, documented in *Decision Basis Document for Implementation of 10 CFR 830 Safe Harbor Requirements for the Silos Projects*, 40000-RP-0034 [Ref. 1], entails the preparation of this Silo 3 Nuclear Health and Safety Plan (N-HASP) prior to initiating access to, and segmented retrieval of, Silo 3 material. The safety basis for the Silo 3 Retrieval and Disposition Project is based on the 10 CFR 830 safe harbor provision for an environmental restoration activity. This safe harbor method relies on the use of DOE-STD-1120-98, *Integration of Environment, Safety and Health into Facility Disposition Activities* [Ref. 5]. Based on this approach, Silo 3 retrieval and disposition was determined to qualify as a RAD Facility based on the analyses discussed in Appendix B, *Hazard Category Calculation*. Although Silo 3 qualifies as nuclear HC-3 based on inventory, retrieval and disposition qualifies as RAD based on analytical consequences. See Section 5.0 for a detailed discussion of this issue.

2002: Fluor Fernald teaming partner Jacobs Engineering Group initiated conceptual design of the new remediation plan, specifying pneumatic retrieval as a predecessor to mechanical retrieval to the extent needed to create a void space behind the proposed wall opening. Design data development studies were initiated to determine the optimum treatment formulas.

Envirocare of Utah proposed that untreated Silo 3 material could be received and disposed of at their facility without treatment due to the material's 11e.(2) classification.

Based on further negotiations with Envirocare and revision of the Nevada Test Site WAC, disposal without on-site or off-site treatment was pursued. The conceptual design for treatment was shelved, and a proposed design change that deleted on-site chemical stabilization treatment was approved. The Preliminary Design, Remedial Design Package, and Technical Baseline for non-treatment was submitted to the USEPA and OEPA, but was not approved.

Fernald Citizens Advisory Board (FCAB) expressed concern regarding dispersibility of the Silo 3 material in the event of a transportation accident. DOE and Fluor Fernald agreed to implement conditioning of the Silo 3 waste, prior to packaging, to reduce its dispersibility.

OEPA suggested the addition of a reducing agent, in conjunction with waste conditioning, to reduce the leachability of the RCRA component chromium VI (discussed in Section 8.19).

DOE and Fluor Fernald agree to apply a reasonable "best efforts" approach to reduction of dispersibility, and reduction of leachability of chromium VI, by adding a waste conditioning process into the current Silo 3 remediation design (i.e., application of binder/stabilizer agents [sodium lignosulfonate and ferrous sulfate] in aqueous solution to the Silo 3 material). Design changes were incorporated via Design Change Notices (DCNs).

DOE-EH-53, Office of Nuclear Safety, issues technical position NSTP-2002-2, *Methodology for Final Categorization for Nuclear Facilities from Category 3 to Radiological* [Ref. 18]. This paper clarifies DOE-STD-1027 final hazard categorization and applies the methodology to classification below HC-3.

2003: 40430-RD-0014, *Revised Proposed Plan for Operable Unit 4 Silo 3 Remediation Action* [Ref. 19] prepared by Flour Fernald, reviewed by DOE, and approved by USEPA and OEPA.

Draft *Record of Decision Amendment for Operable Unit 4 Silo 3 Remediation Action* [Ref. 20] prepared by Fluor Fernald and reviewed by DOE. Following incorporation of DOE comments, the document was submitted to USEPA and OEPA and is awaiting approval.

This Silo 3 Retrieval & Disposition N-HASP developed. Approved in February, 2004, this N-HASP is the documented safety analysis for Silo 3 remediation activities. Design changes will be evaluated via the Silo 3 Safety Basis Impact Screen (SBIS). If proposed changes have the potential to affect the Silos, positive screens will be evaluated using the Unreviewed Safety Question process (see Section 6.0). PCN2

1.4 Silo 3 Process Description

The Silo 3 Retrieval and Disposition Project consists of the following major activities. This Silo 3 N-HASP covers Operation and Maintenance (i.e., Material Removal and Packaging).

- STORAGE AND MAINTENANCE
- CONSTRUCTION
- OPERATION AND MAINTENANCE
  - * Material Removal
    - Pneumatic Retrieval
    - Mechanical Retrieval
  - * Packaging
    - Waste Conditioning
    - Container Filling
    - Filled Container Management
- DECONTAMINATION
- DEMOLITION

Silo 3 PHAR scope

Silo 3 N-HASP scope

When all Silo 3 material is removed, the equipment and structures will be dismantled, decontaminated (when appropriate), and dispositioned.

In the discussions that follow, refer to the following process flow diagram and fold-out pages. These graphics are provided for general information only. To obtain the latest versions, contact Silo Project Document Control.

FIGURE 1-1: SILO 3 OPERATIONS FLOW DIAGRAM
FIGURE 1-2: SILO 3 CIVIL SITE PLAN
FIGURE 1-3: EAST ELEVATION
FIGURE 1-4: 1ST FLOOR PLAN
FIGURE 1-5: SECTION A
FIGURE 1-6: SECTION C
FIGURE 1-7: SECTION D

1.4.1 Basic Silo 3 Operation

To understand the Silo 3 radiological hazards, one must first understand the basic Silo 3 retrieval and disposition operation (see the flow diagram in **FIGURE 1-1**). Waste retrieval is accomplished by pneumatic retrieval and mechanical retrieval (the material was originally transferred into Silo 3 pneumatically). Some material handling and packaging equipment is shared by both systems. The silo itself is enclosed in a fabric structure, which provides protection from the elements to personnel operating the pneumatic retrieval system. Before Silo 3 is accessed for waste retrieval, radon concentrations in the silo headspace will be reduced by venting through the Silo 3 stack. Calculations show that release of all accumulated radon through the stack will not exceed the RQ of .1 Ci (see Appendix D, Table D.3.3).

Retrieval begins with the Vacuum Wand Management System (VWMS) and the Pneumatic Retrieval System (PRS). The VWMS consists of hoist-assisted vacuum wands inserted through existing manways on the silo dome. The VWMS is tied to the PRS inlet, which vacuums material through the manways and transfers it to the Process Building for packaging. The VWMS and PRS are also used to remove material behind the silo wall before creating a wall opening for the mechanical retrieval system.

After a reinforced concrete framework is installed on the silo wall, and a section of the silo wall is removed, the Mechanical Retrieval System (MRS) begins operation (see Section 1.4.2 on the Silo 4 Mock-up). According to 40430-PL-0002, *Access and Retrieval Strategy for the Silo 3 Project* [Ref. 21], it can be concluded that the reinforced silo (with the wall section removed) will be more structurally robust than the present (unmodified) silo wall. A mechanical excavator retrieves compacted material from the silo and transfers it to a bin located in the Excavator Room. Conveyors feed the material to the adjacent Process Building for packaging.

From a design point of view, the PRS and MRS are redundant systems. Either system has the capacity for retrieving the entire store of Silo 3 waste material. Current plans call for the PRS to be used prior to, and in conjunction with, the MRS.

A Feed Conveyor in the Process Building receives material from the PRS or MRS and discharges it to two Package Loading Stands. Each station is a semi-automated system with loading spouts, loading stands, thumper tables, weighing scales, radio frequency (RF) sealer, and motorized roller conveyors for transporting the filled soft-sided containers away. An aqueous solution of ferrous sulfate and sodium lignosulfonate will be sprayed onto the material in the fill chutes to reduce the material's dispersibility and RCRA metal (chromium) mobility. No credit was taken for waste conditioning in the hazard category calculations.

After a soft-sided container is filled, the inner PVC liner is sealed by radio frequency, perforated, and detached from the fill chute at the perforation. The container is moved to the Package Staging Conveyor, where swipe sampling and surveys of the container assembly are performed. If no contamination is found, the container is then transported to the Cargo Container Bay, through an airlock, where it is closed and placed on a shipping pallet. The containers are surveyed to meet shipping requirements and staged for labeling. Once a container has been labeled, it will be loaded into an enclosed truck trailer using a forklift, and transported to a staging area for shipment off-site.

1.4.2 Cutting a Hole in Silo 3 for Mechanical Retrieval

Note: Hole cutting is a construction activity performed by construction labor and authorized by the PHAR. The Silo 4 mock access demonstration was performed during the construction of the retrieval facility. However, Silo 3 wall access will occur after the operations phase has begun because the plan calls for pneumatic retrieval of material behind the intended wall opening. Safety Basis Requirement 1 (Section 10) specifies a deliberate process for proceeding with the wall cutting. Therefore, there will be a short window of time when operations (authorized by this N-HASP) and construction work (authorized by the Silo 3 PHAR [Ref. 14]) will overlap.

Successfully cutting an opening in the Silo 3 wall large enough for mechanical retrieval may be critical to successful project operations if pneumatic retrieval cannot transport the most compacted waste. The project committed to a demonstration of the work steps for cutting such an opening. This demonstration (conducted on now-demolished Silo 4) was designed to verify engineering calculations, support detail vendor design, integrate multiple field activities, analyze observations, and generate lessons learned for subsequent documentation.

Design and preliminary strategies were developed through early collaboration with consultants, engineers, equipment vendors, and construction representatives, including supervisors and craftsmen. An independent structural consultant, considered an expert in reinforced concrete tank design, supported the detailed design. The project bulk powder consultant conducted modeling studies to predict material flow during scenarios that varied by material height at the time of cutting. The overall retrieval approach is documented in 40430-PL-0002, *Access and Retrieval Strategy for the Silo 3 Project* [Ref. 21]. The results of the Silo 4 demonstration are documented in 40430-RP-0028, *Silo 4 Mock-up Demonstration* [Ref. 22]. The following two subsections provide an overview of those results.

Mock Access on Silo 4

In preparation for the eventual access of the Silo 3 wall, a mock access was conducted on empty Silo 4 (since demolished). Silo 4 was built about the same time as Silo 3 by the same contractor, and had the same structural dimensions and characteristics (see Section 1.3.1). The main difference was that the Silo 4 concrete had severe freeze-thaw effects because it had been empty. However, based on the demolition of site water tanks (similarly constructed by the same contractor), the access plan was deemed feasible for Silo 3. The water tanks and Silo 3 are considered comparable in terms of good concrete quality. The added difficulty presented by good-quality concrete was factored into the observation of the Silo 4 demonstration.

A 20ft H x 15ft W opening is required for retrieving material with a remote-operated excavator. The access strategy calls for the intended wall opening to be cut into a grid pattern with a track-mounted wall saw. The outside surface of the silo wall was originally reinforced with post-tensioned wires encased in gunnite. Therefore, a concrete reinforcement frame was designed to maintain the structural integrity of the silos by maintaining the tension of the post-tensioning wires when cut, and preventing their release from the concrete. The design is conservative and provides a safety factor [Ref. 23].

The first step in the mock access was to cast-in-place the concrete reinforcement around the intended access opening. Next, some of the decant ports located on the silo wall were glove-bagged and removed because they interfered with the temporary cutting tracks and planned safety beams.

The plan calls for cutting the concrete in grid sections to facilitate removal and to reduce the amount of rubble that could get into the stored Silo 3 waste. There is also a concern that rubble and the large number of wires in the debris would foul the mechanical equipment in the retrieval bin. The grid plan also allows for concrete sections to be removed from top to bottom. This will be helpful if impacted material has to be removed as the opening is made.

A custom-designed curved tract was ordered to match the curvature of the silo. The track-saw automatically travels on the track and the depth of the cut is controlled by a tethered control. This allows the operator to maintain a safe work distance. The silo wall was scored in a grid pattern with a concrete wall saw to within one inch of the inside surface of the wall. It was determined that a cut of this depth would allow the concrete to be broken free and yet minimize worker exposure to Silo 3 material during the actual cutting. During the cutting, wedges were used to keep the sections stable.

During grid cutting, the severed wires and gunnite were removed. Horizontal beams were installed to prevent cut sections of the wall from falling on workers.

One reason the selected excavator was chosen was because it has an additional articulating joint. This provides a range of motion that allows it to work within the silo and adjoining excavator room. The machine can also articulate in a horizontal plane. This flexibility would support retrieval if only a portion of the wall can be removed due to material compacted behind the wall.

A mounting/lifting bracket was designed to be compatible with the excavator attachment mounting plate and was used for removal of some of the braces. This was found to be quicker and much safer than using a hoist, and could be done remotely. Different types of attachments were used to secure wall sections to the excavator, and those sections were successfully removed. Due to poor concrete quality, the sections fractured rather than remaining as whole sections. However, removal of concrete sections and testing of the excavator swing area within the footprint was demonstrated.

Due to the poor condition of the concrete, the rubble was placed within Silo 4 for later on-site disposal with the other demo debris. Silo 4 has since been demolished. Concrete will be disposed

of in the OSDF as part of the Silo 3 concrete waste stream, or in alternate disposal locations as specified in the Project Waste Identification and Disposition (PWID) report.

The Silo 4 demonstration showed that:

- the reinforced opening was appropriately designed and installed.
- a concrete track saw can be used to score the concrete prior to breaking the opening.
- the excavator can support field activities during the preparation steps of cutting the opening.
- a remote-operated excavator has the break-out force and maneuverability to work in the designed space for removing concrete.
- multiple (and available) tools and attachments are required to break the concrete free and handle pieces.
- the access and retrieval strategy approach is valid.

Silo 3 Access

Silos 3 and 4 were built in the same manner at the same time by the same contractor. They have the same structural dimensions and characteristics. The main difference is the less-degraded quality of the Silo 3 concrete. Based on demolition experience with site concrete water tanks built by the same contractor, Silos 3 and 4 have been determined to present equivalent challenges that can be accessed using the same strategy. Thus, the experience of the Silo 4 demonstration (i.e., reinforcing frame and grid cutting) is directly applicable to Silo 3. A Lessons Learned report was written following the Silo 4 demonstration [Ref. 24]. Detail design has incorporated any recommendations or changes through the project design change notice (DCN) process and safety basis impact screens (SBIS) and Unreviewed Safety Question (USQ) process.

It is a reasonable expectation that the project team associated with the Silo 3 wall cutting will include some of the same individuals who participated in the Silo 4 mock-up. All craft, supervision, and engineering support for Silo 3 penetration will receive training or briefings on the lessons learned, equipment, safety requirements, and work evolutions. Engineers familiar with the lessons learned and the Silo 3 cutting requirements will be made available during the training exercises.

If Silo 3 concrete sections meet the OSDF or WPRAP WAC, they will be removed and wrapped in plastic for staging in the thorium laydown area until disposal in the OSDF or WPRAP as part of the Silo 3 concrete waste stream. Silo 3 concrete that does not meet the OSDF or WPRAP WAC will be containerized and shipped as part of the existing NTS profile/shipping program for "process area waste." Such concrete will be placed directly in strong-tight containers (Sea/Lands).

A number of observations made during the Silo 4 demonstration will improve the Silo 3 access process:

- The vertical cuts through the post-tensioning wires caused delamination of the one-inch shotcrete layer, which affected the mounting of the track for the horizontal cuts. Steps were revised to completely remove the post-tensioning wires and shotcrete layer in the work area (no delaminating was observed past the reinforcing frame).

- After the first track-saw cut, it was easier to remove the cut wires using a hand-held saw. The track mounting was then reset after the shotcrete was removed. Additional track mounting brackets were identified as being needed. One section of scoring cut completely through the wall. On Silo 3, this would cause contamination of the work area. This demonstrated that the project must conservatively assume that a breach will occur and dress workers in appropriate PPE. In the event of a breach, the cut location can be temporarily sealed to contain the material. Additional measurements will be made after the track is reset to check clearances and adjust for silo curvature. Cuts will be made in three passes with the depth of the last cut to be adjusted.

- Installation of the wall braces was cumbersome at Silo 4 because there was no building on which to mount rigging (a manlift was used). For Silo 3, rigging can use the excavator roof structural steel. Improved brackets that braces could slide into would allow quicker installation and removal. A mounting/lifting bracket was designed to be compatible with the excavator attachment mounting plate and was used for removal of some of the braces. This was found to be a quicker and safer than using a hoist, and could be done remotely.

- Scoring of the concrete prior to removal resulted in defined boundaries for each section and allowed for control of the amount of concrete to be removed. The freeze-thaw effects on Silo 4 concrete caused the sections to fracture rather than remaining as whole sections; however, the fracturing remained within the grid. The mounting bracket for segment removal was used and demonstrated. Adjustments were made to the bracket installation work steps. The excavator handled the pieces within the design footprint of the excavator room. The selection of excavator attachments was demonstrated and an assessment of each piece was made.

- Measurements were made for the placement of the cable management system, tethered electric line, and closed-circuit television cameras. Cameras were not available to provide views of the far side from the control area. The operator walking and visually working with the machine was used to document the views and camera locations that will be needed during Silo 3 operations.

The following recommendations will be evaluated by engineering and will be incorporated, as appropriate, into the Silo 3 equipment, design, and work planning [Ref. 22]:

1. Revise the excavator cable management location. Locate camera mounting brackets on the excavator. Paint the boom in contrasting colors for depth perception.

2. Provide additional attachments, such as a modified bucket or tools to address variable concrete conditions, including removal of rubble in addition to whole pieces.

3. Modify the mounting bracket installation.

4. Procure additional mounting brackets and longer hydraulic hoses for the wall saw.

5. Design wall braces that can be remotely removed from the Silo 3 wall opening using the excavator. The brace design will account for live load of Silo 3 material behind the wall.

6. After the final brace design is received, revise the construction traveler to incorporate redline comments and revised work steps. (A construction traveler is a subcontractor-produced, FCP-reviewed/approved work plan that outlines how construction will perform work safely.)

7. Evaluate the need for vertical as well as horizontal braces.

8. Update the safety briefing on equipment and the construction traveler. Prior to initiating Silo 3 penetration, show that the activity can be performed as planned per the Operations Work Instructions specified in this N-HASP (TABLE 10-1, SBR-1).

1.4.3 Silo 3 Material Retrieval and Packaging Activities

This section provides a more detailed explanation of the operational steps of Silo 3 material retrieval and packaging.

Pneumatic Retrieval

Note: Prior to construction, the design of the pneumatic retrieval components will be evaluated against, and conform to, the Technical Safety Requirement (TSR) specified in Section 10.3. The pneumatic retrieval strategy has a demonstration plan [Ref. 25] for vacuum wand retrieval and will separately document the results.

The VWMS is installed on the silo dome beneath a fabric enclosure structure that provides protection from the weather. The VWMS consists of flexible hoses and metal tubes (vacuum wands) that will be inserted through the six existing silo dome manways. A motorized hoist will be used at each manway to assist operators in manipulating the VWMS hoses/wands. Video cameras to allow for remote viewing.

At each vacuum wand (and associated manway), an enclosure is provided with passive air supply (inlet) and process vent (outlet) hose connections. A coated fabric flexible boot is installed on the top of each enclosure to seal around the vacuum wand and prevent particulate emissions from the silo, particularly during times when the vacuum retrieval is not running.

In order to keep silo pressure from becoming too negative, the passive air supply (from a HEPA filter) will replace air displaced during pneumatic retrieval and process vent operations. The process vent connection will normally be used to provide slight negative pressure when vacuum wand sections are added and when the pneumatic retrieval (vacuum) system is not in operation.

A vacuum relief valve on the passive air supply piping will open at 3 inches water column (WC) vacuum in the event the HEPA filter becomes plugged or does not allow sufficient air flow to alleviate silo negative pressure.

In the event of a failure of the passive air supply and/or the vacuum relief valves, the fabric flexible boots around the wands should fail (thus relieving silo negative pressure) before a silo failure occurs. Additionally, there is a pressure transmitter on the silo dome to provide an alarm if the silo pressure becomes greater than 3 inches WC vacuum. The pneumatic system also has a low-

pressure switch on the blower inlet that will open a blower inlet relief valve, and a low-flow switch to shut down the blower in the event of a plug in the pneumatic system or the passive air supply.

The PRS is contained in a steel beam/metal-sided building (the Process Building) adjacent to the silo. The PRS provides pneumatic, vacuum flow using rotary blowers. From the VWMS, the material/air stream enters the PRS baghouse collector, where material is separated from the air stream and fed by a screw conveyor and rotary airlock to the packaging screw conveyor. The air stream from the PRS baghouse collector passes through a cartridge filter, a high-efficiency particulate air (HEPA)/ ultra-low penetrating air (ULPA) filter, and rotary blower and is discharged via the Silo 3 exhaust stack. Material collected by the cartridge filter is fed by the same screw conveyor and rotary airlocks to the packaging screw conveyor.

Pneumatic retrieval will be performed to the extent practicable (i.e., as long as material can be safely and effectively removed by vacuum). Of significant importance is the use of the VWMS/PRS for removal of material from behind the silo wall, at the proposed access location, to permit safe wall opening for mechanical retrieval. The VWMS/PRS can be used prior to the MRS and in conjunction with it.

Mechanical Retrieval

The Mechanical Retrieval System (MRS) is housed in a robust concrete structure (Excavator Building) attached to the silo structure. When free-flowing material has been removed from the silo to expose the inside of the silo wall, and pneumatic retrieval is no longer practical, an opening will be cut into the exposed silo wall to enable the use of a mechanical excavator (see Section 1.4.2). Compacted material remaining behind the wall will not prevent initiation of wall removal.

The selected excavator has an additional articulating joint. This provides a range of motion that allows it to work within the silo and adjoining excavator room. The machine can also articulate in a horizontal plane. This provides flexibility for supporting retrieval if only portion of the wall can be removed due to material impacted behind the wall.

The excavator can reach into the silo and loosen compacted material for vacuuming. Video cameras to allow for remote viewing. The excavator may also be used to manipulate the VWMS wand/hose to facilitate pneumatic retrieval. The remotely-operated excavator will enter the silo and dig into the waste pile. Removed material will be placed in a below-grade bin in the Excavator Room and then moved to the two packaging stations via four conveyors. Three of the conveyors are screw-type, and one is a pocketed sidewall belt conveyor. The last of the screw-type conveyors is common to the PRS.

Waste Conditioning

As the Silo 3 material is containerized, it will be conditioned by the addition of an aqueous solution to reduce dispersibility and metals mobility. The solution of ferrous sulfate, sodium lignosulfonate, and water will be sprayed onto the material in the fill chutes at the packaging stations. No credit was taken for waste conditioning in the hazard category calculations.

Container Filling

For both PRS- and MRS-retrieved waste, the final package is an IP-2-compliant (Industrial Package Type 2) soft-sided, sturdy-but-flexible, polypropylene bulk bag containing a sealed poly-vinyl choride (PVC) liner. The bulk bag measures 72" x 48" x 48". The containers were certified IP-2 via testing per 49 CFR Part 173 [Ref. 26] and Part 178 [Ref. 27]. The test container was filled with 7,000 pounds (minimum) of surrogate material similar in characteristics to Silo 3 material. Two tests were performed using: (1) a surrogate similar to conditioned Silo 3 material; and (2) a surrogate similar to untreated Silo 3 material. Each test article underwent a series of tests, including a Free Drop Test, a Stacking Test, and a Vibration Test. Both test articles completed the test series, demonstrating no loss of material during or after testing. No splits, tears, rips, or damage were observed after testing.

Each of the two Package Loading Stands is a computer-controlled (PLC), semi-automated system with loading spouts, loading stands, thumper tables, weighing scales, sealers, and motorized roller conveyors for transporting the filled bags away from the station. There is a camera in the area to allow remote viewing of bagging operations.

Material will be dropped through the fill chutes into the PVC liner. Once material flow into the container has been started, an aqueous conditioning solution will be sprayed on the material as it passes through the chute. When full, the liner will undergo a heat-sealing procedure that ensures that none of the powdered waste is released to the adjacent work area. The sealed liner is perforated and detached from the chute by tearing at the perforation. The container assembly, (container and loading frame) will move away from the fill chute to be closed, surveyed and labeled. The trimmed-off neck of the liner bag will be retained by the fill chute and expelled into the next liner bag to be filled.

The PRS baghouse collector has high-level switches to provide alarm at High level and shutdown at High-high level. An interlock associated with the packaging stand weight transmitters will stop the upstream conveyor, which in turn stops other upstream equipment. The operator will also be able to observe bag loading via a miniature camera inside the packaging filling head and associated monitor. The operator will also be able to feel the container as it is filled. The operator can stop the equipment when, by visual and/or touch, the bag is full. Bag-filling is totally contained. If a bag is overfilled, there will be no release of material. Excess material can be addressed by vibrating the package to lower the level of material. There is a capability (a port) to vacuum excess material if needed. Vacuum activity would make use of containment (plastic bagging), a work plan, and a Radiation Work Permit (RWP). PCN2

Filled Container Management

After a container is filled and the PVC liner is sealed, the container assembly is moved to the Package Staging Conveyor where swipe sampling and surveys of the container assembly are performed. If no contamination is found, the container is then transported through an airlock to the Cargo Container Bay, where it is closed and placed on a shipping pallet. The containers are surveyed to meet shipping requirements and staged for labeling. Once a container has been labeled, it will be loaded into an enclosed truck trailer using a forklift, and transported to an Interim

Staging Area (ISA) for shipment off-site. Video cameras allow for remote viewing of the process and personnel.

The ISA was constructed in the year 2000 east of Silo 3. It is a 1-acre, 9-inch-thick reinforced concrete pad. A portion of the pad may be used for loading the soft-sided containers onto trucks. Another portion is now designated as the Process Building site. The pad has catch basins, an underground storm water drainage system, and aprons to the new infrastructure road.

On-site Transportation

Silo 3 waste material will be transported to an off-site disposal facility by truck. The on-site transportation process will be the same used for all FCP operations. The Silo 3 waste shippers will become part of the Silo 3 Project.

1.4.4 Retrieval Operations Personnel

Note: The numbers provided below reflect operations personnel planning as of the issuance of this N-HASP. These numbers relate to the data provided in the ALARA Analysis (Appendix D, Table D-8). ALARA data is based on a production rate designed to meet the closure schedule. Once Silo 3 retrieval becomes operational, a number of variables may be adjusted in order to maintain the specified production rate or to complete retrieval sooner (e.g., shift durations, workdays-per-week, crew sizes).

The Silo 3 Project will have four months of start-up and readiness operations (two months equipment/system testing; one month simulated operation using surrogate material; one month Readiness Review). During the six months of regular operations, the PRS will operate for approximately three months and the MRS will operate for approximately three months (based on the presumed layering of loose and compacted material). Silo 3 material processing will operate 4 days/week, 12 hours/day (i.e., a 12-hour shift). PCN2

1.5 Management Responsibility for a Safe Work Environment

Providing a safe work environment is the direct responsibility of Fluor Fernald management. Everyone must share a concern for their own safety, the safety of their co-workers, and the protection of the environment. It must be fully understood by all employees that safety shall take precedence over expediency. It is a condition of employment that all employees work safely and follow established safety rules and procedures.

It is the responsibility and policy of Fluor Fernald to provide a safe work environment for all employees. Fluor Fernald management is committed to the belief that all accidents, injuries and occupational illnesses can be prevented and if an activity cannot be performed safely, it will not be performed. Management fully supports this commitment by ensuring that every employee receives the appropriate training, personal protective equipment, and other resources necessary to execute assigned work activities in a safe and efficient manner.

Management responsibilities for safety are further discussed in Section 2.0, *Integrated Safety Management (ISM) System*.

As part of its commitment to safety, Fluor Fernald maintains a Lessons Learned Program per SH-0025, *Fluor Fernald Lessons Learned Program* [Ref. 28]. Through this program, different projects share information to implements ISM Core Function No. 5, Provide Feedback and Continuous Improvement. The program promotes the recurrence of desirable activities, precludes the recurrence of undesirable activities, highlights best practices, and helps develop innovative ways to solve problems or enhance work safety, efficiency, and cost-effectiveness. The following two subsections list lessons learned from the Waste Pits Remedial Action Project (WPRAP) and the AWR Phase 1 Radon Control System project.

1.5.1 Lessons Learned from WPRAP Applicable to Silo 3

The following lessons from WPRAP Lessons Learned 2003-0013 are applicable to the Silo 3 Project:

- As a result of WPRAP's experience with procedure-based training, Silo 3 has developed process-based training based on the process technical description. Initial training provides operations personnel with a basic understanding of all Silos projects. This is followed by project-specific training on the procedures. This progression of training allows for timely hiring of personnel and for initial training to begin prior to the completion of procedures.

- One area of concern that created potential problems at WPRAP was insufficient radiological baseline data from all areas around the facility at the onset of the project. The Silo 3 Project is developing a project-specific air sampling plan that will include baseline data at start-up prior to operations (see Appendix H).

- Information was shared with Silo 3 relative to WPRAP conveyor failures. This was made a Silos 3 Action Item that is currently being addressed as part of the design review process.

- The ventilation of the Silo 3 Control Trailer is currently being compared with arrangements used at WPRAP. Incorporation of these concepts is expected to result in improvements to the Control Trailer design.

The following lesson from WPRAP Lesson Learned 2004-0003 is applicable to the Silo 3 Project:

- A routine WPRAP review of employee training discovered that on numerous occasions a worker was issued a respirator he was not qualified to wear (i.e., he was not fit tested). Being qualified means completing: (1) annual training in the Basics of Respiratory Protection; (2) annual medical evaluation; (3) and annual fit test for each type of respirator to be used. The completion of these requirements is communicated via a pink Training & Qualification card and a blue Fit Test card. It was determined that an atmosphere of informality, plus inadequate oversight of the issuance program at both the programmatic and project levels, led to inattention to detail (i.e., not checking pink and blue cards).

PCN2

Reviewers concluded that personal accountability should be frequently emphasized to program management, respirator issuers, respirator wearers, and oversight personnel. Periodic independent audits of the respirator program should be performed. Training matrices should be reviewed frequently and personnel approaching training expiration dates scheduled for training. The issuance of RPE should be performed with some degree of formality and attention to detail. A centralized respiratory protection organization should be in place, headed by a named Respirator Protection Manager with clear lines of authority and responsibility within the Safety Department organizational structure. Policies and procedures should only be promulgated from the Respiratory Protection Manager. The use of variances, even if provided for in procedures, should be discouraged but, if used, documented and managed with diligence. Silos Project Radiological Control is providing continual procedural training and knowledge enhancement to all assigned RCTs concerning respirator issuance problems, their causal factors, and corrective actions.

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1.5.2 Lessons Learned from Radon Control System Applicable to Silo 3

The following lessons from RCS Lessons Learned 2003-0003 are applicable to the Silo 3 Project:

- For RCS, the lack of a well-defined and executed design review process resulted in the generation of a significant number of Design Change Notices (DCN's) that adversely impacted the construction schedule and subsequent turnover to operations. The design review process for Silo 3 has been revised to provide further details, including: package description, types and sequence of reviews, and roles and responsibilities of participants.

- The RCS red-line/as-built process provided too much flexibility and lacked sufficient discipline, thereby affecting construction turnover to operations and subsequent testing. For example, red-line changes not based on actual field observation resulted in inaccuracies. The red-line/as-built process for Silo 3 is under revision. A dedicated team will be assigned to gather all red-line changes.

- Document control requirements for execution of Silos Projects were underestimated. RCS Phase I activities were the first project area requiring substantial support from project document control, and delays were encountered in reproduction of drawings and documents. The number of personnel on the document control staff was insufficient to support multiple shift and weekend work activities. Space allocation and staffing for maintenance of Silos documentation and drawings has since been increased.

- Improvements were needed in the RCS Project's definition of submittal requirements in design documents, the development and approval of submittal registers, and the document descriptions contained in submittal registers and the document manager system. Deficiencies resulted in additional workload and nonconformance reports. A visit to a vendor site early in the procurement process was found to be an effective method of improving the quality of vendor submittals. Silo 3 personnel have been going to vendor sites to mitigate these problems.

- RCS Construction Acceptance Tests (CAT) were well planned, tracked, and completed in a highly efficient and organized manner. Early alignment among construction, maintenance, operations, engineering, project readiness, and quality control resulted in a highly successful CAT program. The detailed listing of system components with individual requirements for construction acceptance tests, maintenance actions, loop tests, and quality control inspections enabled the project to maintain an accurate status of all systems during the turnover and startup program. This approach is being carried over to the Silo 3 Project.

- RCS Project management elected to accelerate the completion of construction and start-up through turnover of specific construction packages and subsystems. This process, for the most part, worked well. In early applications however, there were some difficulties in commencing startup testing as the requirements for electrical and control systems associated with each package were not fully defined or did not accommodate the overlap of some systems in the same control panels. Better coordination between construction and operations is necessary to determine system boundaries early in the project to efficiently facilitate the turnover from construction to operations.

  Like RCS, Silo 3 Project construction turnover and start-up is organized by identification of system turnover packages. Electrical and control systems are centralized and the controls of the numerous systems overlap or interface with other systems. Because the Silo 3 Project is larger and more complex than RCS, a significant coordination of system start-ups is routine. The project will focus first on completion of electrical systems, control systems, and utility support systems in support of turnover and start-up of the other systems. Silo 3 Project turnover/start-up is not expected to be free of difficulties; however, the project has been organized for implementation of a disciplined, efficient process.

- RCS encountered operability issues regarding rightsizing motor-operated valves associated with louvers and dampers, under-sized condensate traps without adequate means for draining and collection, and use of manually-operated valves instead of motor-operated valves for installations requiring frequent operation or those with limited accessibility. Rework of valve configurations above the silo domes resulted in increased occupational exposure to personnel. The existence of these types of deficiencies is related to the very aggressive RCS project schedule and the shortcomings in the RCS design review process.

  Silo 3 Project design was also developed and reviewed under a very aggressive schedule. Since issuance of the design/construction documents and drawings, operations and engineering personnel have continued to review the project design against actual construction/installation, resulting in numerous design changes to address technical, operational, and maintenance issues. During start-up, Silo 3 process systems will be operationally tested, prior to actual operations, without radiological material, to confirm adequate operability. Identification of additional deficiencies during start-up remains a possibility in a project of this size and complexity.

- The RCS Project was the first on site to undergo detailed review of software development projects for application in process control systems. Project knowledge of software system management requirements associated with programmable logic controllers was insufficient to demonstrate full compliance with DOE requirements. Deficiencies existed in management

controls, testing, and documentation. Site computer software management directives provided limited guidance with respect to development of software systems at the project level. The project software management procedure was revised and some software verification and validation was required to be performed prior to completion of the independent readiness review. Additionally, project engineering specifications did not fully allow for software interface communications between some control systems. Silo 3 Project is using the new software validation process.

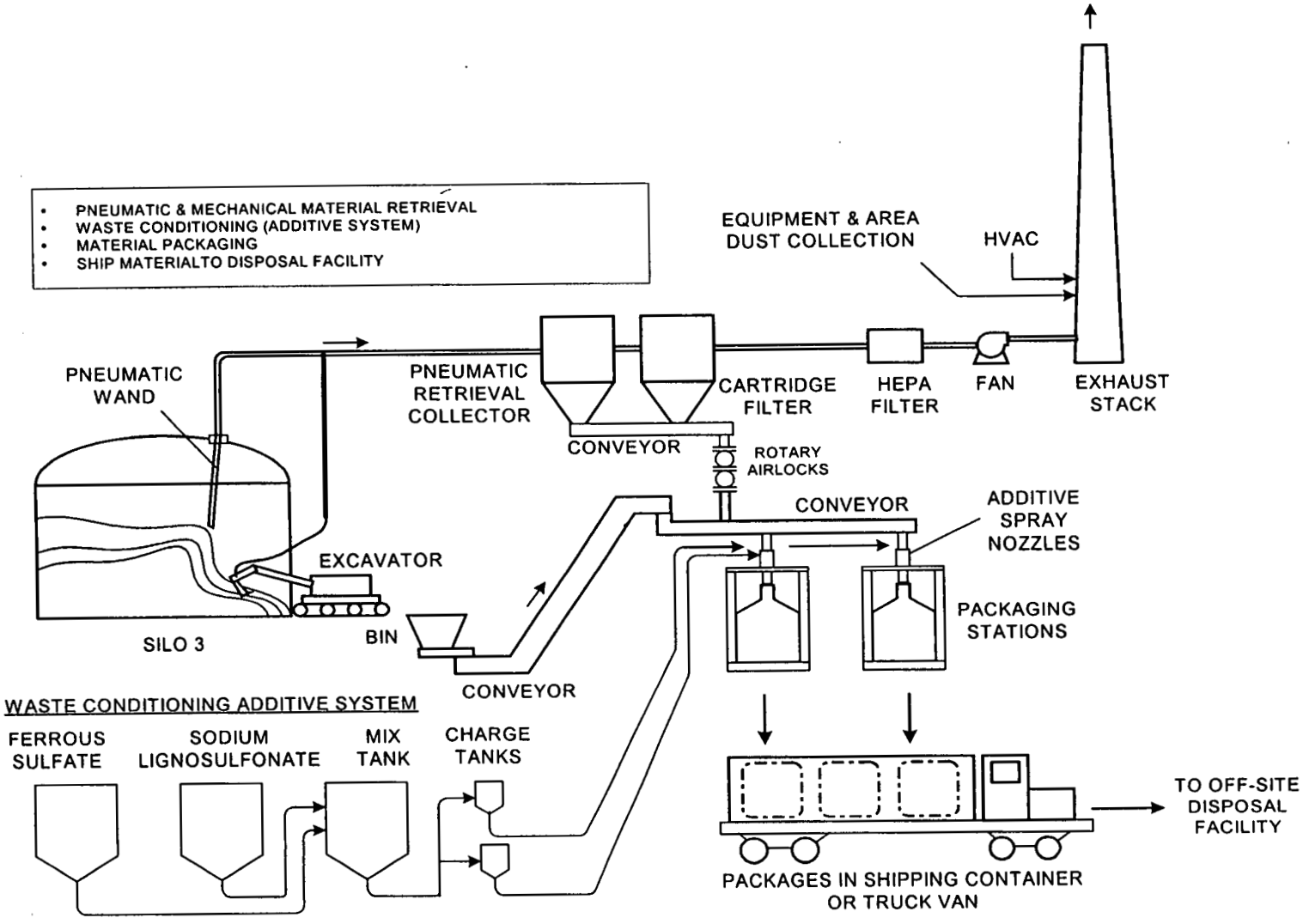
- The use of mockups and demonstrations contributed to the successful startup of the RCS. The RCS system was fully tested using two large sea-land containers to simulate the two silos. This testing enabled the project to better evaluate system performance and correct deficiencies in design and control systems prior to conduct of hot test (radiological) operations. Process engineers, supervisors, and operators demonstrated a high level of knowledge and proficiency during readiness reviews as a result of hands-on training with the mockup system. The Silo 3 Project conducted a successful mock-up silo access on Silo 4 (see Section 1.4.2) as well as a mock-up packaging process at the vendor site.

- A number of last-minute changes to RCS procedures and other documentation impacted operations training and readiness as the aggressive schedule afforded limited time for implementation. As a result of these changes, both the project's management assessment team and the independent readiness review team had difficulty in understanding the procedures and processes being utilized by the project. A second issue with last-minute changes was the potential for not fully evaluating the impact on other related documents. This second factor produced a snowballing effect that was only resolved by making more last-minute changes. It was also important to note that the reason for changes, including comments and resolution, should be carefully documented. Too many situations repetitively arose as to why a specific design condition, standard, set point, or limit existed without the project being able to easily defend (and document) a previously accepted position.

  The Silo 3 Project has attempted to minimize last-minute changes by continuing to review project design against actual construction/installation in an organized by-system-turnover-package manner. Even so, there may still be last-minute changes; however, current efforts are expected to keep last-minute changes and project impacts to a minimum.

- RCS personnel could not make necessary and timely handwritten changes to procedures while on shift due to the very conservative site administrative process for handwritten changes. The current process is not responsive to the needs of around the clock operational type activities. A streamlined procedure has now been outlined in the FCP Document Program. However, in order for this process to be implemented in Silos, DOE approval is required on changes to the FCP Conduct of Operations (CONOPS) Program. These changes are currently under DOE review.

FIGURE 1-1: SILO 3 OPERATIONS FLOW DIAGRAM



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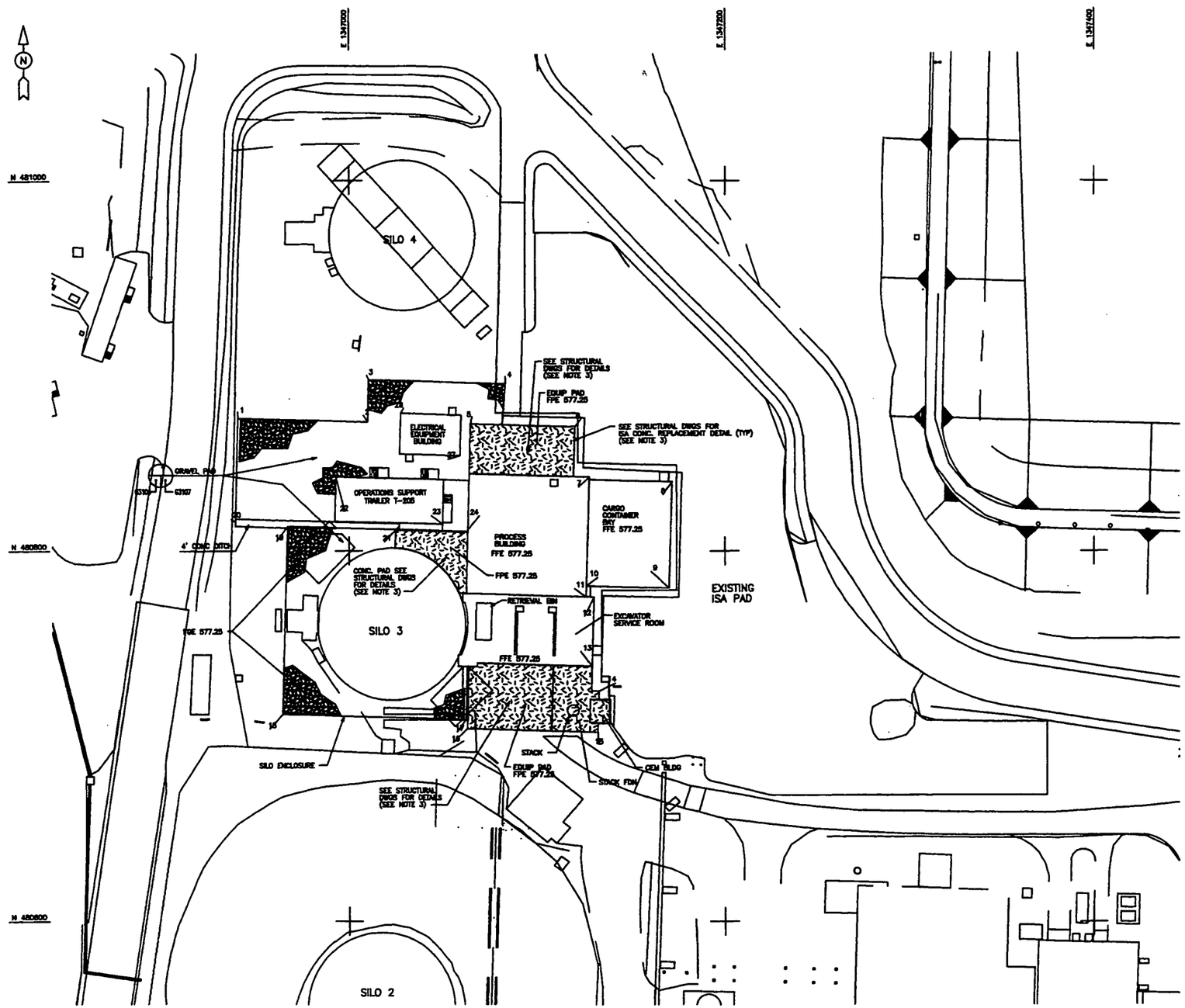

NOTES:

1. FOR GENERAL NOTES AND LEGEND SEE SHEET G3102.
2. FOR GENERAL ARRANGEMENT SEE SHEET M0001.
3. FOR STRUCTURAL FOUNDATIONS AND BUILDINGS SEE SHEET S0120.

COORDINATE LISTING

POINT NO.	NORTHING	EASTING
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2	480569.58	1347010.47
3	480562.67	1347011.10
4	480560.54	1347085.39
5	480565.71	1347087.59
6	480567.24	1347121.57
7	480539.85	1347129.07
8	480537.32	1347172.94
9	480780.01	1347171.37
10	480781.21	1347127.47
11	480778.38	1347127.31
12	480776.26	1347131.58
13	480737.94	1347130.54
14	480724.50	1347134.17
15	480702.26	1347133.56
16	480704.12	1347085.59
17	480705.96	1347084.80
18	480711.76	1346963.34
19	480813.22	1346968.12
20	480815.17	1346937.57
21	480813.28	1347027.44
22	480840.00	1346962.77
23	480814.37	1347062.10
24	480811.10	1347065.85
27	480861.35	1347061.75
28	480874.36	1347028.29

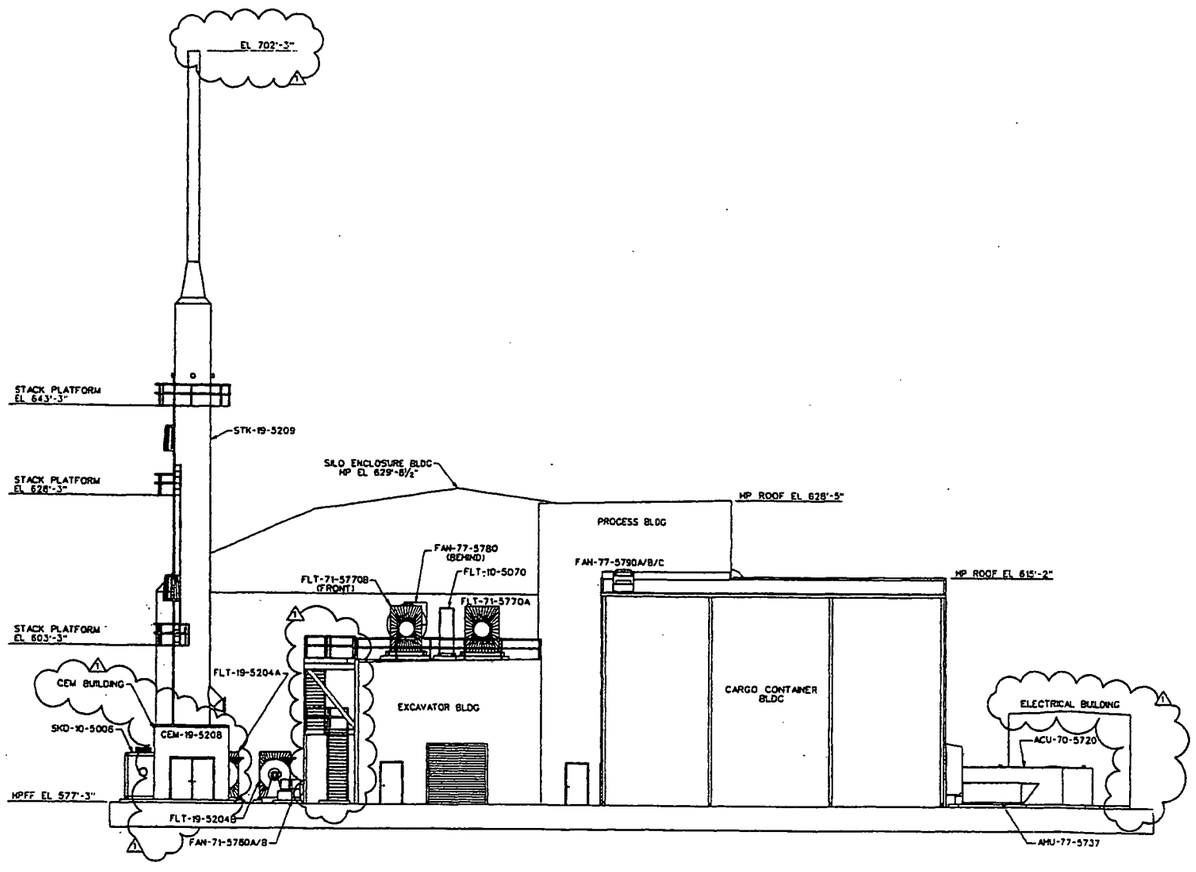
FIGURE 1-2
Pages 23/24

000036

REFERENCE DRAWING NO.	THIS DRAWING PREPARED BY FLUOR FERNALD SILOS PROJECT CINCINNATI, OHIO PROJECT NAME SILOS PROJECT	UNITED STATES DEPARTMENT OF ENERGY FERNALD ENVIRONMENTAL MANAGEMENT PROJECT	DRAWING TITLE CIVIL SITE PLAN SILO 3	CADFILE SK40430DCN0073 CADSIZE AUTOCAD 2000 DRAWN BY J. THOMPSON DATE 8/13/03 DESIGNED, CHECKED BY DATE CHECKED BY DATE PLANT/BLDG. NO. OU4 FLOOR SCALE NONE CLASS SUBMITTED FOR APPROVAL A-E DATE APPROVAL RECOMMENDED OPERATING CONTRACTOR DATE DOE PROJECT NO. OPER. CONTR. PROJ. NO. 40430 DRAWING NO. SK40430DCN0073 SHEET NO. 1 REV. NO. A

INITIALS: JBT DATE: 8/13/03

FIGURE 1-3
Pages 25/26



EAST ELEVATION

SCALE: 1/8" = 1'-0"

GENERAL NOTES:

1. ALL EQUIPMENT DESIGNATORS ARE EXPLAINED ON THE P&ID LEAD SHEETS (i.e. M0001, M0002, AND M0003).
2. ABBREVIATIONS ARE AS FOLLOWS:
   HP HIGH POINT
   EL ELEVATION
   HPFF HIGH POINT OF FINISHED FLOOR
3. ALL DIMENSIONS NOT LOCATING EQUIPMENT ARE REFERENCE ONLY.

#050

REF DWG NO.	DRAWING TITLE

REV. NO.	ISSUE OF REVISION PURPOSE - DESCRIPTION	DATE	REV. BY	APPR.
1	REVISED PER DCN 40430-JEG-043, -034, -042	11-7-03	MPM	JTN
0	ISSUED TO CONSTRUCTION	07/11/02	MPM	JTN

DETAILS AND DATE

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

THIS DRAWING PREPARED BY
JE JACOBS

PROJECT NAME
SILO 3

DRAWING TITLE
MECHANICAL
GENERAL ARRANGEMENT
EAST ELEVATION

DRAWN BY	DATE	TECHNICAL LEAD	DATE	CHECKED BY	DATE
D. DAVIS	07/11/02	J.T. NELSON	07/11/02	MICHAEL MALONE	07/11/02

PLANT/BLDG NO.	FLOOR	SCALE	CLASS
	N/A	½" = 1'-0"	U

SUBMITTED FOR 30% ISSUE	SUBMITTED FOR 90% ISSUE	SUBMITTED FOR 100% ISSUE
TECH LEAD	TECH LEAD	TECH LEAD
DATE	DATE	DATE

T.O. NUMBER	PROJECT NO.	DRAWING INDEX CODE NO.	SHEET NO.	REV. NO.
N/A	40430			
J.E.P. PROJECT NO. 35H39905	FILENAME 94030463.DGN	94X-3900-M-01463	M0002	1

DATE: 04/04/03 TIME: 09:35:46 AM
USER: DDAVIS
DESIGN FILE: J:\FMDP\DWG\M\M0002.DGN

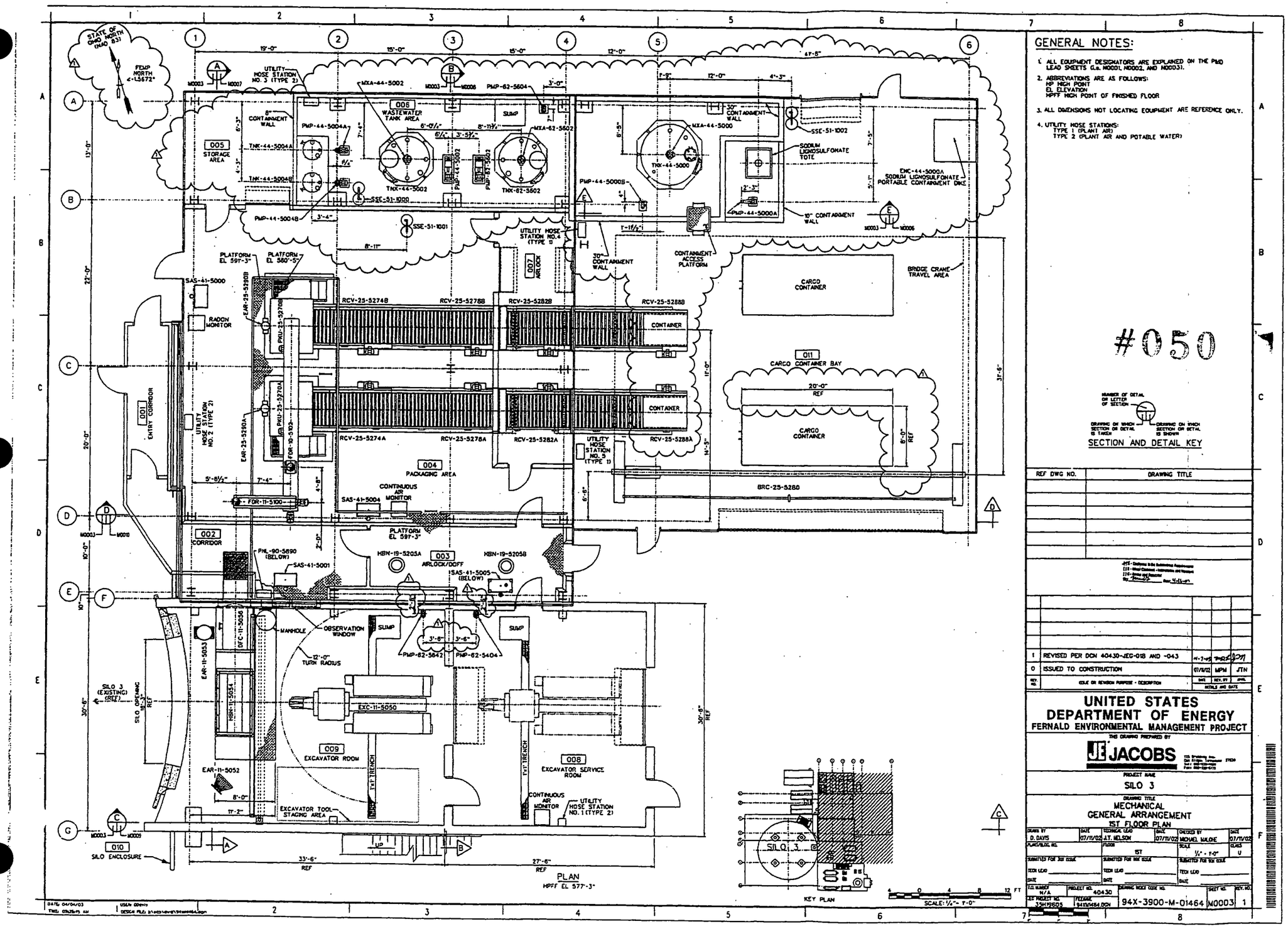


FIGURE 1-4
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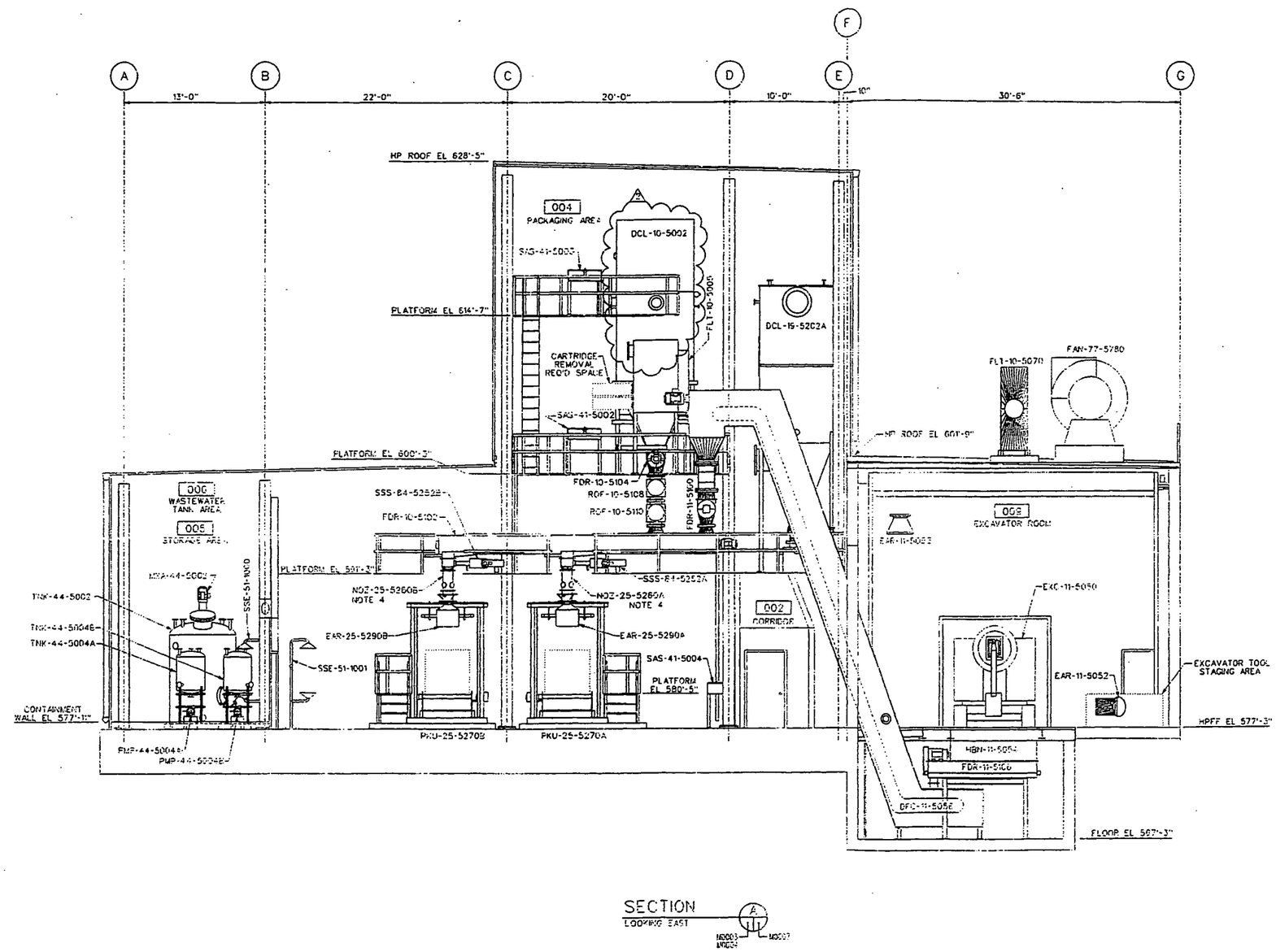

SECTION
LOOKING EAST

SCALE: 1/2" = 1'-0"

GENERAL NOTES:

1. ALL EQUIPMENT DESIGNATORS ARE EXPLAINED ON THE P&ID LEAD SHEETS (i.e. N0001, N0002, AND N0003).
2. ABBREVIATIONS ARE AS FOLLOWS:
   HP HIGH POINT
   EL ELEVATION
   HPFF HIGH POINT OF FINISHED FLOOR.
3. ALL DIMENSIONS NOT LOCATING EQUIPMENT ARE REFERENCE ONLY.
4. THE PACKAGING SAMPLERS MAY BE DELETED FROM THE SILO 3 DESIGN. FLUOR FERNALD, INC., IS TO BE CONSULTED BEFORE PROCUREMENT/INSTALLATION OF THIS EQUIPMENT.

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FIGURE 1-5
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NUMBER OR LETTER OF SECTION — DRAWING ON WHICH SECTION OR DETAIL IS TAKEN — DRAWING ON WHICH SECTION OR DETAIL IS SHOWN

SECTION AND DETAIL KEY

REF DWG NO.	DRAWING TITLE

#050

2	REVISED PER DCN 40430-JEG-055	4/5/03	MDL	JTN
1	REVISED PER DCN 40430-JEG-043	04/07/03	MDL	JTN
0	ISSUED TO CONSTRUCTION	07/11/02	MPM	JTN
REV. NO.	ISSUE OR REVISION PURPOSE - DESCRIPTION	DATE	REV. BY	APP.

STATUS AND DATE

UNITED STATES DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

THIS DRAWING PREPARED BY
JE JACOBS

PROJECT NAME
SILO 3 000039

DRAWING TITLE
MECHANICAL
GENERAL ARRANGEMENT
SECTION A

DRAWN BY	DATE	TECHNICAL LEAD	DATE	CHECKED BY	DATE
G. DAVIS	07/11/02	J.T. NELSON	07/11/02	MICHAEL MALONE	07/11/02

PLANT/BLDG. NO.	FLOOR	SCALE	SIZE
	N/A	1/2" = 1'-0"	D

SUBMITTED FOR 30% ISSUE	SUBMITTED FOR 60% ISSUE	SUBMITTED FOR 90% ISSUE
TECH LEAD	TECH LEAD	TECH LEAD
DATE	DATE	DATE

F.O. NUMBER	PROJECT NO.	DRAWING NO.	SHEET NO.	REV. NO.
N/A	40430	947-3900-M-01467	M0007	2

CAD PROJECT NO.	FILENAME
35H19605	94XM467.DGN

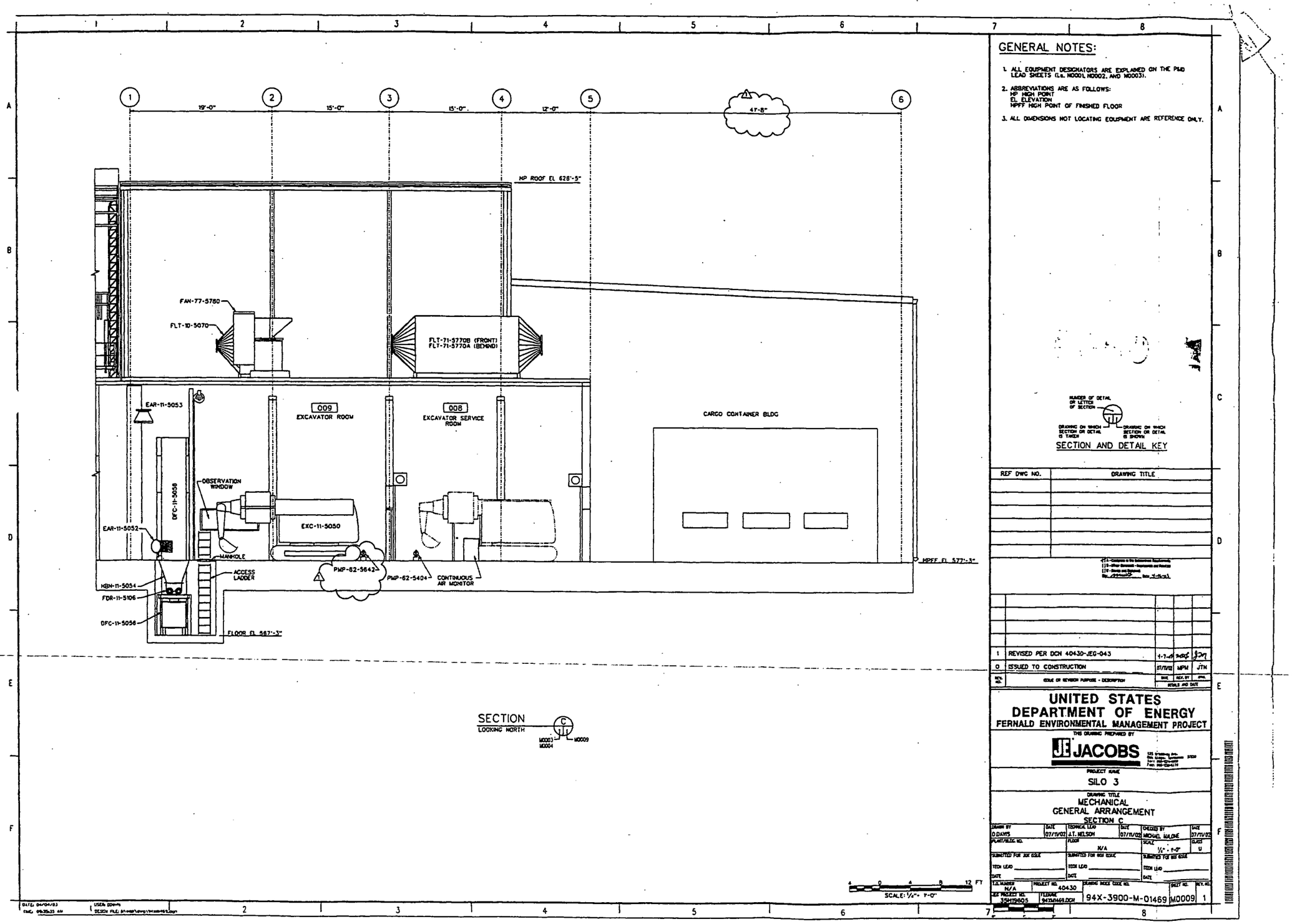
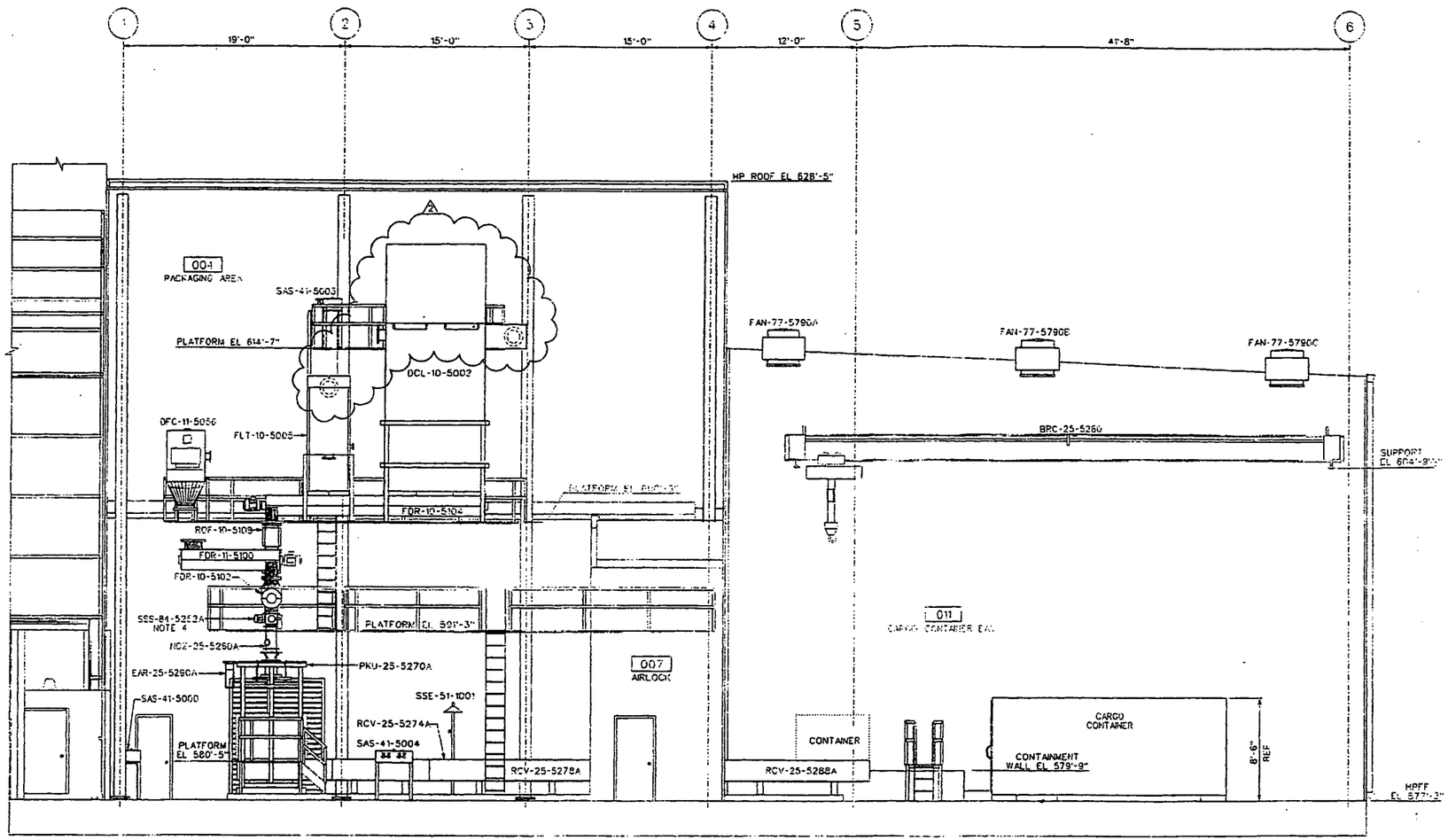


FIGURE 1-6
Pages 31/32



SECTION
LOOKING NORTH

GENERAL NOTES:

1. ALL EQUIPMENT DESIGNATORS ARE EXPLAINED ON THE P&ID LEAD SHEETS (i.e. N0001, N0002, AND N0003).
2. ABBREVIATIONS ARE AS FOLLOWS:
   HP HIGH POINT
   EL ELEVATION
   HPFF HIGH POINT OF FINISHED FLOOR
3. ALL DIMENSIONS NOT LOCATING EQUIPMENT ARE REFERENCE ONLY.
4. THE PACKAGING SAMPLERS MAY BE DELETED FROM THE SILO 3 DESIGN. FLUOR FERNALD, INC. IS TO BE CONSULTED BEFORE PROCUREMENT/INSTALLATION OF THIS EQUIPMENT.

FIGURE 1-7
Pages 33/34

MARKER OF DETAIL OR LETTER OF SECTION
DRAWING ON WHICH SECTION OR DETAIL IS TAKEN
DRAWING ON WHICH SECTION OR DETAIL IS SHOWN
SECTION AND DETAIL KEY

REF DWG NO.	DRAWING TITLE

#050

Key - Conform to the following designations:
1 B - Minor Comment - Incorporate and Resubmit
1 C - Review and Resubmit
Sig. [illegible] Date 6/6/03

REV NO.	ISSUE OR REVISION PURPOSE - DESCRIPTION	DATE	REV BY	APPR.
2	REVISED PER DCN 40430-JEG-065	6/05/03	[illegible]	JTN
1	REVISED PER DCN 40430-JEG-043	04/08/03	MDL	JTN
0	ISSUED TO CONSTRUCTION	07/31/02	MFM	JTN

REVISIONS AND DATE

UNITED STATES DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

THIS DRAWING PREPARED BY
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125 Broadway Ave.
Oak Ridge, Tennessee, 37830
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Fax: 865-220-4175

PROJECT NAME
SILO 3 000041

DRAWING TITLE
MECHANICAL
GENERAL ARRANGEMENT
SECTION D

DRAWN BY	DATE	TECHNICAL LEAD	DATE	DESIGNED BY	DATE
D. DAVIS	07/31/02	J.T. NELSON	07/31/02	MICHAEL MELGRAE	07/31/02

PLANT/BLDG. NO.	FLOOR	SCALE	CAD
	N/A	1/4" = 1'-0"	0

SUBMITTED FOR 30% ISSUE	SUBMITTED FOR 90% ISSUE	SUBMITTED FOR 90% ISSUE
TECH LEAD:	TECH LEAD:	TECH LEAD:
DATE:	DATE:	DATE:

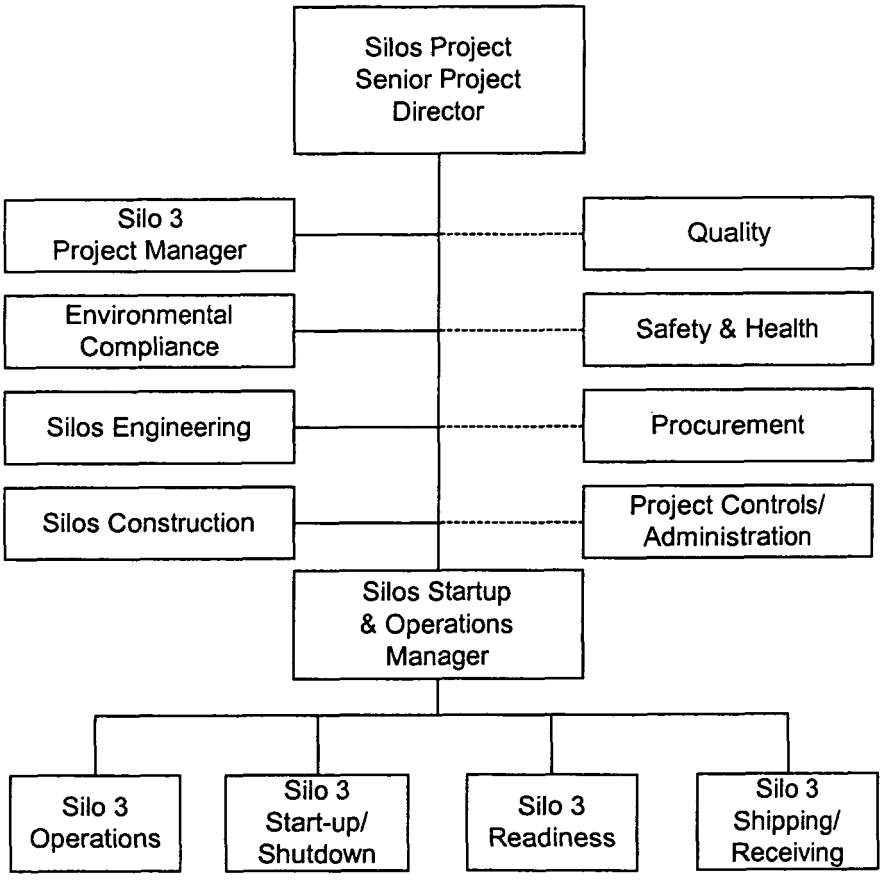
I.D. NUMBER	PROJECT NO.	DRAWING INDEX CODE	SHEET NO.	REV. NO.
N/A	40430			
JE PROJECT NO. 35H19605	FERNAP 94XM4750/A	94X-3900-M-D1470	M0010	2

SCALE: 1/4" = 1'-0"

1.6 Silo 3 Project Organization

The Silo 3 Project has organized a team with the extensive technical and administrative experience necessary to successfully complete the overall Silos retrieval and disposition project. The Silos Project is divided into three sub-projects: the Advanced Waste Retrieval (AWR) Project (which includes the Radon Control System), the Silos I & 2 Remediation Project, and the Silo 3 Project. To support these projects, the Silos Project uses common technical experts. As the Silos projects continue to develop through normal execution phases, the roles and responsibilities will be appropriately transitioned to efficiently provide the required support. The Silos Project organization chart is periodically updated and maintained on the Fernald Intranet. The Silo 3 organization chart is shown **FIGURE 1-8**. Future activities not currently represented are Safe Shutdown, Decontamination and Demolition, and Soils Remediation.

FIGURE 1-8: SILO 3 PROJECT ORGANIZATION CHART



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Silos Senior Project Director (SPD)

The Silos Senior Project Director (SPD) is responsible for all aspects of the Silos Project (AWR, Silos 1 and 2 Remediation, and Silo 3). The SPD is the primary interface for the Fluor Fernald Leadership Team, the DOE, as well as the numerous regulatory agencies and community groups interested in Silos Project activities. The SPD is the Executive Account Approval Manager for all Silos Project accounts and the staffing manager for the Silos Project. In keeping with the principles of Integrated Safety Management (ISM), the SPD is responsible for the safety of the worker, the public, and the environment throughout the Silos Project.

Silo 3 Project Manager (PM)

The Silo 3 Project Manager (PM) is responsible to the Silos SPD for the execution of all aspects of the Silo 3 Project, including baseline development and management, design engineering, procurement activities, technical contractor oversight and compliance management, and safe shutdown. The PM is responsible for the safe, cost-effective, and timely implementation of the work scope and functional area requirements contained in the applicable sections of the *Silos Project Execution Plan* [Ref. 29]. The PM is also responsible for the development and negotiation of key project milestones and for being responsive to applicable regulatory agencies and stakeholders. The Silo 3 PM coordinates project activities with the Silos Functional Area Managers. Additionally, the PM is the delegated CAM authority for the Silo 3 Project.

Silos Safety and Health (S&H) Manager

The Safety and Health Manager (S&H) is matrixed to the Silos Project from the Safety, Health and Quality (SH&Q) Division. The S&H Manager is responsible to the Silos SPD for identification and resolution of safety and health issues, and for coordination of Silos Project safety and health resources with other Fluor Fernald projects, divisions, and programs. The S&H Manager supports the Silo 3 Project with regard to Occupational Safety and Health (OS&H), Radiological Engineering, Emergency Preparedness, Nuclear and Systems Safety (NSS), Fire Protection, and Security functional areas.

- For OS&H, the S&H Manager will ensure that the Silo 3 Project implements a program compliant with applicable regulatory guidelines to provide a safe working environment for team members.

- For Radiological Engineering, the S&H Manager will ensure that the Silo 3 Project maintains a program compliant with applicable regulatory guidelines and provides a radiologically safe working environment for all team members.

- For Emergency Preparedness, the S&H Manager will ensure that the Silo 3 Project maintains plans, coordination, and programs compliant with applicable regulatory guidelines to provide a safe working environment for all team members.

- For NSS, the S&H Manager will ensure that the Silo 3 Project provides the administrative support and technical activities required for protecting the environment and health and safety of the public in the event of an accident. The S&H staff is responsible for providing guidance on

required safety basis documentation, reviewing configuration management issues, and supporting hazard analyses. The analyses include the Integrated Hazard Analysis (IHA), Human Factors Evaluation (HFE), and As Low As Reasonably Achievable (ALARA) analysis, through the Safety Analysis Department.

- For Security, the S&H Manager will maintain a liaison with Fluor Fernald Security to ensure that the Silo 3 Project maintains a program compliant with applicable regulatory guidelines for personnel access and control of property.

Silos Construction Manager (CM)

The Silos Construction Manager (CM) reports to, and is responsible to, the Silos SPD for coordination of all construction activities performed in support of the Silos Project (including Silo 3). The CM will coordinate all planning, documenting, and oversight activities associated with the construction of Silo 3 systems and facilities. The CM will coordinate with the Silos EM to ensure integration of engineering deliverables to support Silo 3 construction and overall project schedules. The CM is responsible for providing constructability reviews for Silo 3 based on submittals. The CM will drive completion of the Construction Acceptance Testing (CAT) as part of the process of turnover to operations. The CM will direct the activities of procurement and contracts administration to meet the field needs, as well as other support areas such as field safety, quality control, and radiological support. The CM will interface with SH&Q for assurance of proper work authorization, safety, and quality in all construction activities. The CM will interface with Startup, Readiness, Operations, and Maintenance functions to ensure timely and effective turnover of constructed systems and facilities to Operations.

Silos Engineering Manager (EM)

The Silos Engineering Manager (EM) reports to, and is responsible to, the Silos SPD. The EM is responsible for ensuring that all design tasks are completed in a manner compliant with the programs and procedures of the Fluor Fernald Site Engineering Group. The Silos EM is responsible for design configuration management and design change control work processes. The Silos EM will support the Silo 3 Project Engineering Lead's efforts to appropriately document and coordinate the engineering activities. The Silos EM is also responsible for all technical studies performed for the Silo 3 Project, for overall engineering documentation, and for all support provided by Title 3 (construction support) and home office technical personnel.

Silos Startup and Operations (S&O) Manager

The Silos Startup and Operations (S&O) Manager reports to, and is responsible to, the Silos SPD for coordination and integration of all Silos startup, readiness, operations, and maintenance functions (including Silo 3). This includes integration of the Waste Management function in Silos.

Silos Operations Manager (OM)

The Silos Project Operations Manager (OM) reports to the Silos S&O Manager and is responsible for ensuring operation and maintenance of all facilities required for the remediation of the silos and the material currently stored in the silos. The OM is responsible to each of the individual projects (including Silo 3) with regard to operation and maintenance of the facilities to meet the safety, schedule, quality, and regulatory goals. The OM will be responsible for project interface with FAT&LC for labor coordination and any industrial relations processes. The OM will be responsible for development and administration of all training support required to assure that all operations and support staff training requirements are identified and fulfilled.

Silos Startup/Shutdown Manager (SSM)

The Silos Startup/Shutdown Manager (SSM) reports to the Silos S&O Manager and is responsible for the startup of all facilities required for silos remediation (including Silo 3), and for validation of completion of all safety, regulatory, contractual, design, and quality requirements. The SSM plans and coordinates the transition from Silo 3 construction completion to turnover to Operations, including completion of all component and systems operational testing in accordance with a startup and test program. The completion of the Silo 3 facility startup and test program will transition the operable facility to the Silos Project O&M Manager. The SSM will ensure that lessons learned from each Silo Project startup are shared with the project functional managers for future improvement. The SSM is also responsible for operations planning in support of post-operations and safe shutdown activities.

Silos Readiness Manager (SRM)

The Silos Readiness Manager (SRM) reports to the Silos S&O Manager and is responsible for verifying that facility safety documentation is in place and that procedures, personnel, equipment, and systems support the necessary requirements for the start of operations. The SRM will develop a readiness plan of action consistent with a graded approach to minimum core requirements and ISM principles to bring the facilities to a state of readiness to safely commence operations. The SRM will coordinate self-assessment activities with all functional area leads in preparation for independent startup verification reviews and also will coordinate with any site and DOE teams involved in these processes

Silos Quality Manager (QM)

The Quality Manager (QM) is matrixed to the Silos SPD for coordination of all quality functional areas within the division. The QM is also responsible to the Fluor Fernald QC Project Operations Manager to perform tasks in a manner compliant with the requirements of Fluor Fernald quality programs and procedures. The QM will supervise and support the efforts to appropriately document and coordinate Silo 3 Project QA/QC activities. The QM is also responsible for special quality control functions associated with packaging and shipping hazardous waste materials. The QM will ensure that lessons learned from all on-going Silos Project activities are shared with the project functional managers for future improvement. PCN2

Silos Procurement Manager

The Procurement Manager is matrixed to the Silos SPD and is responsible for supporting the Silos Project with regards to management of contracts, preparation of solicitations, evaluation of offers, contract negotiation, contract award, procurement of materials and services, and administration of contract performance and change orders.

Silos Project Controls/Administration Manager (PCM)

The Project Controls/Administration Manager (PCM) is matrixed to the Silos SPD and is responsible for establishment of a work breakdown structure, budgeting and funding the baseline scope, cost control and invoicing, baseline change management, schedule control, and resource management for the Silos Project. The PCM will develop and communicate appropriate project metrics to indicate status and performance against key project goals and requirements.

Silos Environmental Compliance Manager (ECM)

The Environmental Compliance Manager (ECM) reports directly to the Silos SPD and is responsible for compliance with all regulatory requirements for Silos as well as other site activities. The ECM will also serve as the relationship manager with the agencies.

Silos Shipping and Receiving Manager (SRM)

The Silos Shipping and Receiving Manager (SRM) reports to the S&O Manager and is responsible for receiving bulk materials, consumables, trailers, and empty containers. The SRM is also responsible for characterization of waste scheduled for shipment, and for container loading and shipping.

1.7 Silo 3 Workplace Hazards Analysis

A quantitative analysis of the hazards associated with the construction, operations, and maintenance tasks for Silo 3 was performed per Fluor Fernald requirements. Guidance was taken from 10 CFR 830 [Ref. 2], DOE-STD-1027-92 [Ref. 30], and the Occupational Safety and Health Administration (OSHA) 29 CFR 1910.119 [Ref. 31] and 29 CFR 1910.120 [Ref. 3]. The objectives of the analysis were to:

- identify and evaluate hazards contained in the facility/process to establish a sound technical basis for their control.
- establish worker safety controls to reduce and mitigate hazards.
- establish Process Requirements (PRs) to ensure that the activities remain safe in accordance with good management practices, routine conditions, and anticipated operating modes.
- establish Safety Basis Requirements (SBRs), which limit the activities based on a direct association with its analyzed safety envelope and current Hazard Categorization or classification.

The analysis was performed by a diverse team integrating all safety functional areas (radiation protection, industrial hygiene, industrial safety, nuclear safety, fire protection, and emergency preparedness) along with operations, maintenance, quality assurance, engineering, and a facility owner.

The methods used by the team to determine the safety envelope included:

- Integrated Hazard Analysis (IHA)
- Hazard Category Calculations (HCC)
- Human Factors Evaluation (HFE)
- Occupational ALARA Analysis
- Environmental ALARA Report
- Fire Hazards Analysis (FHA)
- Accident Analysis

Complete descriptions and details of these analyses can be found in Volume II of this N-HASP.

2.0 INTEGRATED SAFETY MANAGEMENT (ISM) SYSTEM

The purpose of the Integrated Safety Management (ISM) system is to ensure the integration of safety into all facets of Silos work planning and execution. Specific responsibilities for implementation of ISM are assigned to both DOE and Fluor Fernald line management. The objective is to systematically integrate safety into management and work practices at all levels so that missions are accomplished while protecting the public, the workers, and the environment. The ISM program is described in PL-3081, *Safety Management System Description (SMSD)* [Ref. 32].

ISM is incorporated into the Silos Project and will be incorporated into any contracts awarded to support this work scope - thus assuring that the precepts of ISM flow down to all subcontractors. All subcontractors are fully expected to meet the contract requirements pertaining to the integration of environmental, safety, and health requirements into work planning and execution. Contractors are expected to work safely without accident, injury, or insult to the environment. Any contracts associated with this project will specifically state that the contractor shall ensure that management of environment, safety, and health (ES&H), pollution prevention, and waste minimization functions and activities become an integral yet visible part of their work planning and execution process. This will assure that ISM program requirements flow down to subcontractors.

The Seven Guiding Principles of ISM

1. Line Management Responsibility for Safety - All levels of management are responsible for safety. Line management is directly responsible for the protection of the public, the workers, and the environment. The term line management means all levels of leadership in the organization responsible for accomplishing a particular mission, either project or programmatic.

2. Clear Roles and Responsibilities - Clear lines of authority and responsibility for ensuring safety are established and maintained at all organizational levels. The leadership responsible for accomplishing project or programmatic work is also responsible for ES&H.

3. Competence Commensurate with Responsibilities - Personnel must possess the experience, knowledge, skills, and abilities that are necessary to perform their responsibilities.

4. Balanced Priorities - Resources are effectively used. Safety costs are an integral part of the total cost of accomplishing the work scope. Another aspect of integration is the fusion of safety planning with the business process, such as budget and resource allocation. A first step is to translate missions into work requirements in conjunction with the prioritization of budget and resources.

5. Identification of Safety Standards and Requirements - Before work is performed, the identified hazards are evaluated and an agreed-upon set of safety standards and requirements is established that will provide adequate assurance that the public, the workers, and the environment are protected from adverse consequences.

6. Hazard Controls Tailored to Work Being Performed - Administrative and engineering controls to reduce and mitigate hazards are tailored to the work being performed and identified hazards.

7. Operations Authorization - The conditions and requirements for operations to be initiated and conducted are clearly established, agreed upon, and addressed. This process is further defined in the Contractors' Work Plans and is accomplished through preparation of appropriate safety documentation and demonstrations of readiness. In addition, work control documents (e.g., Work Plans and permits) may include conditions that must be satisfied for work to proceed.

   Readiness documentation will be published separately as a part of the Silo 3 Start-up and Turnover Plan of Action. This documentation will be reviewed and approved separately by the DOE.

The Five Core Functions of ISM

1. Define the Scope of Work - Missions are translated into work, expectations are set, tasks are identified and prioritized, and resources are allocated.

2. Analyze the Hazards - Hazards associated with the work are identified, analyzed and categorized.

3. Develop and Implement Hazard Controls - The overall safety envelope is established and controls are implemented. Applicable standards and requirements are identified and agreed-upon, controls to prevent or mitigate hazards are identified, the safety envelope is established, and controls are implemented.

4. Perform Work within Controls - Documentation is to be followed to perform the work, readiness is confirmed, and work is performed safely.

5. Provide Feedback and Continuous Improvement - Feedback information from inspections, assessments and appraisals. Feedback information on the adequacy of controls is gathered, opportunities for improving the definition and planning of work are identified and implemented, and line and independent oversight is conducted. Feedback and continuous improvement is documented in the activity specific work management system.

ISM Work Authorization Flowdown for the Silo 3 Project

The following list presents the ISM flowdown of work authorization documents for the Silo 3 Retrieval and Disposition Project. This flowdown moves from sitewide authorization to general Silos Project authorization to Silo 3 operations authorization.

Sitewide Work Authorization Flowdown

- DOE Policy 450.4, *Safety Management System Policy* [Ref. 33], and the Department of Energy Acquisition Regulation (DEAR) Clause, 48 CFR 970.5204-2 [Ref. 34], requires that a safety management system shall be used to integrate safety into management and work practices at all levels.

- DE-AC24-010H20115 [Ref. 35] is the contract between FCP and DOE which specifically identifies which standards and requirements that FCP needs to follow, as well as requiring FCP to work safely.

- RM-0016, *Management Plan* [Ref. 36], describes how FCP maintains the standards and requirements identified in Contract No. DE-AC24-010H20115. The Management Plan also lists the key site documents which serve to flow down the ISM requirements at the site.

- The *Safety Management System Description (SMSD)*, PL-3081 [Ref. 32], provides an overview of the programs, policies, and procedures used by FCP to ensure that work is performed safely.

Silos Project Work Authorization Flowdown

To facilitate the mission of "Safely restoring the Fernald site to an end state which serves the community's needs," FCP establishes projects, managed by project directors, to accomplish the required remediation activities. The Silos Project is one of the critical site projects. It is divided into three sub-projects: the Advanced Waste Retrieval (AWR) Project (including the Radon Control System), the Silos I & 2 Remediation Project, and the Silo 3 Project. Construction activities for these three sub-projects are governed by the same work authorization process:

- The *Silos Project Execution Plan*, 40000-PEP-0001 [Ref. 29], provides an overview of the Silos Project and references documents that outline how project-specific and program-specific requirements are implemented. This plan describes the project scope, requirements, roles and responsibilities, and systems for executing work in a safe manner consistent with ISM.

- CT-2.1.1, *Construction Project Planning and Construction Invitation for Bid/Request for Proposal (IFB/RFP) Preparation* [Ref. 37] governs the development of construction work packages. Once a contract is awarded, a Notice to Proceed and an Authorization to Mobilize

are sent to the subcontractor. A construction kick-off meeting is held during which FCP safety and health expectations are reiterated.

- 40000-PL-0013, *Silos Construction Health and Safety Plan* [Ref. 38] governs construction activities for the AWR, Silos I & 2 Remediation, and Silo 3 Projects. The Silos Construction HASP identifies applicable OSHA, DOE, and FCP safety requirements related to construction. This HASP also covered the Silo 4 demonstration hole cutting and the Silo 3 hole cutting (which will occur after the operations phase has begun [see Operations flowdown below]).

- Based on the Silos Construction HASP and the corresponding contract (which contains a safety and health section known as "Part 8"), each subcontractor develops a work plan discussing how activities will be performed safely. The work plan is reviewed and approved by Construction and Safety & Health personnel. The Wise Services subcontractor uses work plans called "Construction Work Control Traveler Packages" to outline how they will perform work safely. Each Traveler Package is reviewed and approved by the Construction Contracts Manager, Construction Engineer, Quality Assurance, and Safety & Health personnel.

- Work permits are generated to ensure that appropriate hazards associated with construction activities are analyzed and appropriate controls are developed. The work permit also identifies other required permits (e.g., flame permit, chemical hazardous permit, penetration permit). The supervisor-in-charge and Safety & Health personnel approve each work permit.

Silo 3 Project Operations Work Authorization Flowdown

- 40430-PL-0010, *Silo 3 Retrieval and Disposition Nuclear Health and Safety Plan* (this document), identifies applicable OSHA, DOE, and FCP safety requirements. Upon DOE approval, this Silo 3 N-HASP will ensure that hazards have been identified, and that controls/mitigators will be in place, to support the safe operation of the Silo 3 retrieval and disposition process.

  Note: With one exception, operations will take place after construction is complete. Hole cutting is a construction activity performed by construction labor. The Silo 4 mock access demonstration was performed during the construction of the retrieval facility. However, actual Silo 3 wall access will occur after the operations phase has begun because the plan calls for pneumatic retrieval of material behind the intended wall opening. Therefore, there will be a short window of time when operations and construction work will overlap.

- Silo 3 Project standing orders and procedures have been, and will continue to be, developed to identify hazards and inform Operations personnel how to work safely. Work is initiated in accordance with procedure, usually by the supervisor.

- Readiness documentation will be published separately as a part of the Silo 3 Start-up and Turnover Plan of Action. This documentation will be reviewed and approved separately by the DOE.

3.0 WORK CONTROLS

Hazards and their control mechanisms are communicated to the Fluor Fernald workforce through standard policies, plans, and procedures. This Health & Safety Plan defines and communicates Silos project hazards and the controls required to mitigate those hazards.

At the task level, job planners are required to consider the level of competency required for each job. This includes consideration for training, experience, use of walkdowns, and pre-job briefings. Proper work planning ensures that the workers have all the materials, training, equipment, supervision, and technical support necessary to perform the assigned task successfully, safely, and efficiently.

Individual tasks also rely on job briefings, radiological and industrial work permits, and other hazard-specific mechanisms used to protect the worker. Employees are responsible for understanding the scope of the work, including hazards and controls, prior to initiating a task. Job planners are required to consult S&H personnel in the areas of industrial, radiological, and chemical hazards to ensure that the strategy for mitigation of one hazard does not increase the risk or change the mitigation strategy for another.

All employees, including subcontractors, are involved in providing feedback through the safety work groups and/or safety representatives. This approach ensures that employees with the greatest knowledge of the work evaluate the work planning and execution processes. Safety First work groups identify and resolve issues pertaining to work process safety.

4.0 CONDUCT OF OPERATIONS

Operations activities will be organized, staffed, and administered to ensure a disciplined approach to performance of work consistent with site operations and maintenance requirements. Integrated Safety Management (ISM) core functions and guiding principles (see Section 2.0) will be integrated into management and work practices at all levels so that the workers, the public, and the environment will be protected.

The site policies and requirements established for Conduct of Operations (CONOPS) will be implemented through the Silos Project Standing Orders using a graded approach. Site policies and requirements will be consistent with DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities* [Ref. 39] (applicability as described in RM-0029, *Conduct of Operations (CONOPS) Program* [Ref. 40]). Operations management will develop standards of performance to serve as benchmarks for accountability. Operating procedures and other definitive documentation will define requirements and the types of controls necessary for the safe and successful conduct of work. Silos Project personnel will be cognizant of safety and health requirements, including knowledge of expected hazards and the controls governing the safe operation of facilities and activities. PCN2

The operations and maintenance organizations will be adequately staffed and trained to perform operations and work activities in a safe, professional manner consistent with administrative processes, site and project operating procedures, and work control documents. The Silos O&M Group will provide management, first-line managers and supervisors, and operations and maintenance personnel. FAT&LC operators and maintenance personnel will perform operations and maintenance functions.

5.0 SAFETY BASIS

The Safety Basis for the Silo 3 Retrieval and Disposition Project is based on the safe harbor provision in 10 CFR 830, *Nuclear Safety Management* [Ref. 6], for an environmental restoration activity. This approach satisfies a commitment in the DOE-approved *Decision Basis Document Implementation of 10 CFR 830 Safe Harbor Requirements for the Silos Projects,* 40000-RP-0034 [Ref. 1]. Per DOE's *Safety Evaluation Report* [SER] *for Implementation of 10 CFR 830 Safe Harbor Requirements for the Silos Project, 40000-RP-0034* [Ref. 41], Fluor Fernald will bring all three Silos into this safe harbor.

The 10 CFR 830 safe harbor method for environmental restoration activities relies on the use of DOE-STD-1120-98, *Integration of Environment, Safety and Health into Facility Disposition Activities* [Ref. 5]. DOE-STD-1120-98 allows certain nuclear facility remediation activities to be conducted using 29 CFR 1910.120 and 29 CFR 1926.65 requirements in lieu of the safety management requirements in the nuclear safety orders. DOE-STD-1120-98 further requires continuation of the QA rule (10 CFR 830.120 Subpart A) and the DOE Occurrence Reporting Processing System (ORPS). The contractor is required to submit to DOE documents generated under the alternative regulations for review and approval prior to work (in this case, Health and Safety Plans [HASPs]).

DOE-STD-1120-98 specifies that the DOE safety management orders applicable to the "in lieu of" alternative process include: Safety Analysis Report (SAR), Unreviewed Safety Question (USQ), Technical Safety Requirement (TSR), Training and Certification, CONOPS, and Maintenance. It further states that the Health and Safety Program and HASPs, which include elements for emergency response, training, conduct of operations, and maintenance, may be used in lieu of the nuclear safety orders.

This Silo 3 N-HASP meets the requirements of 10 CFR 830.204, *Documented Safety Analysis* (DSA), 29 CFR 1910.120 (b)(4), *Project Specific Health and Safety Plan,* and follows the general rules for HASP development as outlined in NS-0005, *Initiating, Reviewing, and Approving DOE-Approved SBDs* [Ref. 4]. The term "Nuclear HASP" does not derive from the categorization of the Silo 3 Retrieval and Disposition Project, but rather, from the integration of System Safety functions into a standard OSHA HASP.

Silo 3 N-HASP development is consistent with the technical position NSTP-2002-2, *Methodology for Final Categorization for Nuclear Facilities from Category 3 to Radiological* issued in 2002 by DOE-EH-53, Office of Nuclear Safety [Ref. 18]. This paper clarifies DOE-STD-1027 final hazard categorization and applies the methodology to classification below HC-3. It states:

> *The HC-3 threshold values for radionuclides for which the food pathway or the inhalation pathway are limiting may be revised if, based on the physical and chemical form and available dispersive energy source for the facility and its hazardous materials, the credible release fractions (airborne release fractions) can be shown to be significantly different than the values used in the EPA Technical Background Document.*

Silo 3 retrieval and disposition has been determined to qualify as a RAD Facility based on the analyses discussed in Appendix B, *Hazard Category Calculation*. Although Silo 3 qualifies as nuclear HC-3 based on inventory, the retrieval and disposition activities and facilities qualify as RAD based on analytical consequences. Per DOE-STD-1120-98, *Integration of Environment, Safety and Health into Facility Disposition Activities* [Ref. 5], a RAD categorization/classification based on analytical consequences requires DOE approval. This N-HASP specifies (in Section 10.0) System Safety Requirements that provide defense-in-depth.

Volume One of this N-HASP contains the standard requirements of a 29 CFR 1910.120 HASP, into which have been inserted sections addressing the Silo 3 System Safety Requirements and the Work Control Processes related to Silo 3 process. Volume Two includes the supporting analyses performed to develop the Silo 3 System Safety Requirements (i.e., IHA, HCC, HFE, ALARA Analysis, Environmental ALARA, HFE, Accident Analysis, and HPP). Together, Volumes One and Two comprise a DSA that meets the requirements of 10 CFR 830.204, *Nuclear Safety Management*.

With DOE's approval of 40000-RP-0034, *Decision Basis Document Implementation of 10 CFR 830 Safe Harbor Requirements for the Silos Projects*, the following Silo 3 commitments have been identified:

- Proceed with development of the DSA[s] (i.e., HASP[s]), using the methodology specified in 10 CFR 830, Subpart B, Appendix A, Table 2, Item 6. Item 6 allows the use of a HASP in lieu of the SAR, USQ, TSR, Training and Certification, CONOPS, and Maintenance requirements specified in DOE Orders.

- Continue with implementation of the QA rule (10 CFR 830.120 Subpart A) and the DOE ORPS. These requirements can be met by following the site requirements documented in RM-0012, *Quality Assurance Program* [Ref. 42], and SH-0028, *Occurrence Reporting* [Ref. 43].

- Continue to analyze future activities, using the *Silos Project Safety Basis Impact Screen*, to ensure they are within the current safety envelope. If a change leads to a positive screen indicating the change could exceed the defined envelope, develop the appropriate analysis. If analysis indicates the change will be outside of the safety envelope, prepare an Unreviewed Safety Question Determination/Safety Evaluation (USQD/SE) and submit it to DOE for approval prior to implementation of the planned activity.

- Annually review and update the HASP[s], as necessary. If there are no significant changes required to the HASP[s], meet the annual update requirement via a letter to DOE stating there have been no significant changes.

The following commitment from the DOE SER 40000-RP-0034 has been identified by the Silo 3 Project as applicable to Silo 3:

- Fluor Fernald, Inc., must maintain the safety programs as described in the site Integrated Safety Management program description documented in PL-3081, *Safety Management System Description (SMSD)* [Ref. 32].

6.0 MANAGEMENT OF CHANGE

NOTE: With the approval of this Silo 3 N-HASP, Silo 3 personnel will no longer use the Silos Project Safety Basis Impact Screen (SBIS) for Silo 3 Project change issues. For Silo 3 changes, personnel will use the Silo 3 SBIS documented in this section. Changes to approved Silo 3 operating procedures, and approval of new Silo 3 operating procedures, must go through the review process specified in the site document control procedure, MS-2001. The Silos Project SBIS is still valid for Silos change issues outside the scope of any approved Silos N-HASP.

Since the Preliminary DSA (i.e., Silo 3 Preliminary Hazard Analysis Report (PHAR) [Ref. 14]) was approved, changes to the design or variations in construction from the design have been screened using the *Silos Project Safety Basis Impact Screen* (SBIS). Upon Silo 3 N-HASP approval, a *Silo 3 Safety Basis Impact Screen* must be completed: (1) for changes in design requiring a Design Change Notice (DCN) per an engineering procedure; (2) for new activities; (3) for maintenance alterations; (4) for changes to this N-HASP. The Silo 3 screen is shown in **FIGURE 6-1**. Both the Silos Project screen and the Silo 3 screen meet the requirements of NS-0008, *Safety Basis Documentation Review (SBDR) Process* [Ref. 44].

A System Safety Analyst [SSA] must approve the impact screen. After DOE approval of this N-HASP, any change that results in a YES to any of the five questions on the Silo 3 SBIS will require further evaluation. Question 1 focuses on both nuclear safety and occupational safety (e.g., the Hazards Analysis could be affected by the introduction of a new chemical in the maintenance process, requiring further evaluation). Question 1 allows the screen originator to take an ISM approach to a potential hazard not previously identified. The evaluation will then provide input to the work plan or work permit used for the activity. Question 2 ensures that the System Safety Requirements are not affected by the change. Questions 3, 4, and 5 evaluate potential inadequacies, effects to nearby or adjacent facilities or activities, and changes in inventory of hazardous material.

When a change or deviation requires further evaluation, either the change will not be implemented or work on the affected portion of the facility will remain suspended until an evaluation has been completed and attached to the impact screen. This screen package will then go to the Silo 3 PM for review and approval.

Because the silos themselves are HC-3 facilities, when proposed changes have the potential to affect the Silos, positive impact screens will be evaluated using USQ process per NS-0002, *Unreviewed Safety Question (USQ) Determination and Safety Evaluation System* (USQD/SE System) [Ref. 45]. Potential SBR/PR violations that affect the Silos will be evaluated using the Safety Analysis Evaluation Process listed in NS-0002.

All completed Safety Basis Impact Screens or USQD/SEs will be evaluated annually by Nuclear and System Safety (N&SS) staff for inclusion into this N-HASP to ensure that each document is complete and up-to-date.

Surveillances will be performed by N&SS staff and approved by the N&SS Manager to ensure that the project Safety Requirements are being implemented and the safety basis is being kept up-to-date.

Readiness activities will include a review of the SBIS process to ensure that the DCNs that were performed against the PHAR were properly incorporated into this N-HASP.

Software Management of Change

The Silo 3 Project uses the process outlined in MS-1040, *Software Quality Assurance* [Ref. 46], to classify, develop, verify, and validate software that may have an impact on nuclear safety. This process applies to software currently in use, proposed for use as well as software that is purchased, developed in-house, licensed from a commercial vendor for customized use, obtained from another site, or developed or customized by a vendor or subcontractor.

FIGURE 6-1: SILO 3 SAFETY BASIS IMPACT SCREEN (SBIS)

Description of Activity/Design Change:	
Work Plan/ Design Doc. No.:	**Change Originator:**
SBIS Originator:	**SBIS Date:**

1	Will the proposed change affect any parameters used in calculations supporting the Hazard Analysis as documented in the Silo 3 N-HASP? ☐ **YES** ☐ **NO** **/ EXPLAIN:**
2	Will the proposed change affect any of the System Safety Requirements in the Silo 3 N-HASP? • Safety Basis Requirements (SBRs)? • Process Requirements (PRs)? ☐ **YES** ☐ **NO** **/ EXPLAIN:**
3	Does the proposed change identify a potential inadequacy (e.g., new accident, hazard) in the Silo 3 N-HASP or any potential reduction in any SBR? ☐ **YES** ☐ **NO** **/ EXPLAIN:**
4	Does the proposed change affect the activities or requirements of a nearby or adjacent facility or activity operating under a different safety basis (e.g., Silos 1 & 2, RCS, TTA)? **NOTE: IF** a proposed change can potentially affect the Silos, **THEN** a USQD/safety evaluation must be completed per NS-0002 (Unreviewed Safety Question (USQ) Determination. ☐ **YES** ☐ **NO** **/ EXPLAIN:**
5	Does the proposed change result in a change in the inventory or amount of hazardous material? ☐ **YES** ☐ **NO** **/ EXPLAIN:**

IF the answer to ANY of these questions is **YES, THEN:** (1) update the analysis; (2) determine whether the change will put the project or affected project outside the safety envelope; (3) incorporate any mitigators or controls into the work plan/permit; (4) attach the updated analysis to this impact screen. **IF** the change will result in a higher hazard categorization, **THEN** a USQ must be performed per NS-0002 and submitted to the SRC, the Fluor Fernald President, and the DOE for concurrence.

6	Per this SBIS, the proposed change ☐ **DOES** ☐ **DOES NOT** impact the Silo 3 safety basis.

Signature: _____ **Date:**
System Safety Analyst

SSA: Are there descriptive changes not requiring analysis, but requiring inclusion in the annual update? ☐ **Y** ☐ **N**

NOTE: IF there is an impact to the safety basis, **THEN** the Project Manager's signature is required.

Signature: _____ **Date:**
Silo 3 Project Manager

7.0 HAZARDS ASSESSMENT

The hazards assessment associated with this N-HASP will focus on the activities necessary to support operations and maintenance of Silo 3. To date, fourteen Silo 3 operations tasks have been identified for routine performance by Fluor Fernald maintenance and operations personnel, and one by construction personnel (#15):

NOTE: The hazards associated with these tasks may act as initiators for potential nuclear accidents; if so, they are addressed in Appendices A, B, and G.

1. Truck transport of empty containers and containerized additive materials
2. Receipt of Silo 3 bulk chemicals
3. Manipulation of the Pneumatic Retrieval System (PRS) vacuum wand and hose
4. Maneuvering of the Mechanical Retrieval System (MRS) remote control vehicle
5. Conditioning and packaging of retrieved waste
6. Loading of containerized material
7. On-site transportation of containerized waste materials
8. Maintenance of the Pneumatic Retrieval System (PRS), Air Handling Systems, and Process Vent System
9. Maintenance of motorized vehicles
10. Maintenance of conveyors, feeders, and packagers
11. Maintenance of cranes
12. Maintenance of Waste Additive System and Wastewater System
13. Maintenance of Plant/Breathing Air System
14. Shift-by-shift surveillance of Silo 3
15. Cutting a hole in the Silo 3 wall structure (Note: This is Construction work)

The identified hazards listed below are based on the potential exposure of personnel to the Standard Industrial Hazards, chemical hazards, and radiological hazards posed during Silo 3 operations and maintenance activities. A brief description of the expected hazards and their associated controls are provided in Section 8.0. A Hazards Control Matrix is presented in Section 9.0. This matrix identifies the above tasks in conjunction with their hazards and their controls/ mitigators. The matrix forms the basis for employee briefings.

1. Slips, trips, and falls
2. Noise
3. Housekeeping
4. Illumination
5. Ergonomics
6. Head impact
7. Pinch/Crush Points
8. Ladders
9. Hand and power tools
10. Electrical
11. Hazardous energy
12. Hoisting and rigging
13. Confined space
14. Flammable material
15. Hot work
16. Compressed gas
17. Biological
18. Environmental
19. Heat and cold stress
20. Heavy Equipment
21. Radiological
22. Chemical

8.0 HAZARDS DESCRIPTION

There are numerous physical hazards associated with the performance of Silo 3 operations and maintenance activities. Similar hazards may be encountered throughout the site. The following sub-sections provide the most commonly encountered physical hazards and the mitigating actions for protecting personnel, the public, and the environment. Safety performance requirements (SPRs) are a key part of the Occupational Health and Safety Program at the FCP, and implement the seven guiding principles of ISM. They are not to be confused with Safety Basis Requirements, covered in Section 10 of this document. Also, the listings below are key elements, but not necessarily a complete listing. They are listed here to heighten awareness for the Silo 3 project, not limit requirements.

8.1 Slip, Trip, and Fall Hazards

Uneven terrain, adverse weather conditions, and inattention to housekeeping may present slip, trip, and fall hazards. The uneven surface of the Silo 3 dome presents similar hazards.

NOTE: The safety performance requirements (SPRs) in Table 8-1 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual* [Ref. 47].

TABLE 8-1: SLIP, TRIP, AND FALL HAZARD CONTROLS (SPR 2-1)

1	Maintain the floor or ground surface of work areas flat, even, and free of ice, snow, debris, and if possible, in a dry condition.
2	Keep aisles, passageways, platforms, and stairways free of materials and debris.
3	Ensure that exits, approaches to exits, and hallways are unobstructed and accessible at all times.
4	Obtain Silo Dome Access Permit before performing work on the dome surface.

8.2 Noise Hazards

Operation of Silo 3 includes running fans, generators, and other equipment that can produce loud excessive noise. The effects of excessive noise can include:

- Workers being startled, annoyed, or distracted.
- Physical damage to the ear, excessive pain, and temporary or permanent hearing loss.
- Communication interference that might increase potential hazards due to the inability to warn of danger and the proper safety precautions to be taken.

NOTE: The SPRs in Table 8-2 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual*.

TABLE 8-2: NOISE HAZARD CONTROLS (SPR 2-14)

1	Fluor Fernald monitors for excessive noise levels using sound level meters and/or personal noise dosimeters. Areas with consistently high [>85 decibel (dBA)] noise levels shall be posted with signs notifying personnel that hearing protection is required.
2	All Silos project personnel (including visitors) must wear hearing protection in areas where noise levels are known to exceed, or are expected to exceed, an 8-hour time-weighted average (TWA) of 85 dBA.
3	All on-site personnel must comply with the Fluor Fernald Hearing Conservation Program (available for review from the Silos S&H representative).
4	In some cases, the use of hearing protection may impede workers' ability to hear messages broadcast over the Emergency Message System (EMS). When EMS messages cannot be heard, use alternative methods of communication to ensure that personnel are made aware of these messages in a timely manner. Alternatives: the radios; visual indicators such as flashing lights or waving arms; direct conversation.

8.3 Housekeeping Hazards

Failure to maintain personnel access-ways free of obstructions and failure to maintain the work area free of debris are potential housekeeping hazards.

NOTE: The SPRs in Table 8-3 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual*.

TABLE 8-3: HOUSEKEEPING HAZARD CONTROLS (SPR 2-1)	
1	Maintain work areas in a clean, orderly, and sanitary condition.
2	Maintain floor and work surfaces free of walking and tripping hazards.
3	All tools shall be put away and debris cleaned-up at the completion of assigned work.
4	Use appropriate containers for waste disposal.
5	Keep stairways, passageways, access ways free of materials, supplies, and obstructions at all times.

8.4 Illumination Hazards

The Illumination standards from 29 CFR 1926.56 [Ref. 48] specified in the following table will be observed. In areas of suspected insufficient lighting, Industrial Hygiene will be contacted prior to implementation of field activities and temporary lighting will be provided.

TABLE 8-4: ILLUMINATION HAZARD CONTROLS

Item No.	Foot-Candles	Area or Operation
1	5	General site area
2	3	General construction areas, concrete placement, excavation and waste areas, access ways, active storage areas, loading platforms, refueling, and fuel maintenance areas.

TABLE 8-4: ILLUMINATION HAZARD CONTROLS		
Item No.	**Foot-Candles**	**Area or Operation**
3	5	Indoors: warehouses, corridors, hallways, and exit ways.
4	5	Tunnels, shafts, and general underground work areas: (exception: minimum of 10 foot-candles is required at tunnel and shaft heading during drilling, mucking, and scaling. Bureau of Mines approved cap lights will be acceptable for use in the tunnel heading.)
5	10	General construction plant and shops (e.g., batch plants, screening plants, mechanical and electrical equipment rooms, carpenter shops, rigging lofts and active storerooms, barracks, or living quarters, locker or dressing rooms, mess halls, and indoor toilets and workrooms.)
6	30	First aid stations, infirmaries and offices.

8.5 Ergonomic Hazards

The requirements of the ergonomics program is to reduce or eliminate personnel exposures that could result in occupational injuries and illnesses. The focus of the program is to make the job fit the person, not the person fit the job, and thereby eliminate or reduce musculoskeletal disorders in the workplace. The FCP designs work methods to reduce static, extreme and awkward postures, repetitive motions, and excessive force. Engineering techniques, where feasible, are the preferred method of control.

NOTE: The SPRs in Table 8-5 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual*.

TABLE 8-5: ERGONOMIC HAZARD CONTROLS (SPR 2-6)	
1	Enhance the workplace by implementing, evaluating, and assessing wellness, fitness, and Video Display Terminal (VDT) ergonomics.
2	Present a VDT ergonomics training session to VDT users when requested.
3	Provide training on ergonomics and other hazards associated with a job or process, their prevention or control, and their medical consequences.

TABLE 8-5: ERGONOMIC HAZARD CONTROLS (SPR 2-6)	
4	Perform workstation assessments upon employee requests or as a result of employee injury.
5	Perform workstation analysis to identify existing hazards and conditions, operations that create hazards, and areas where hazards may develop. • Conduct an analysis of injury and illness records. • Conduct comprehensive, qualitative baseline screening surveys. • Analyze all planned new and altered equipment. • Perform a routine ergonomics job-factor analysis.
6	Recommend how to improve or eliminate hazards.
7	Conduct regular safety audits with emphasis on ergonomics.
8	Support acquisitions as necessary.

8.6 Head Impact Hazards

During the performance of work in the Silo 3 facility, opportunities exist for personnel to impact their heads on piping, structural supports, etc. Therefore, head protection must be worn, as required by the work control documents.

NOTE: The SPRs in Table 8-6 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual*.

TABLE 8-6: HEAD IMPACT HAZARD CONTROLS (SPR 2-2)	
1	Wear hard hats when: • designated on the FCP Work Permit or any other applicable document. • in posted area such as construction and crane operation areas. • operating a powered mobile lift platform. • working under personnel in elevated locations (6 feet or higher) or where overhead hazards exist. • within the swing radius of a mobile crane or aerial lift. • in (or under) the basket of an aerial platform. • in or near an excavation. • in manholes or other confined spaces where overhead hazards exist.

TABLE 8-6: HEAD IMPACT HAZARD CONTROLS (SPR 2-2)	
2	Wear hard hats that are in good condition.
3	Throw away damaged hard hats (i.e., cracked, ragged, worn, or defective).
4	Do not alter hard hats.
5	Wear hard hats brim to the front. • Welder hats may have to be reversed to accommodate welding face shields. • When not welding, wear hats brim to front. • Surveyors hats have to be reversed to accommodate use of transit.
6	Cowboys style hard hats are not approved for use at the FCP.

8.7 Pinch Point, Puncture/Cut Hazards

Workers are provided, and required to wear, leather work gloves or other styles of gloves appropriate for the type of work they are performing. Work area walkdowns are used to develop measures to prevent injuries by identifying potential pinch points and sharp edges so that incidental contact is avoided.

NOTE: The SPRs in Table 8-7 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual.*

TABLE 8-7: PINCH POINT, PUNCTURE/CUT HAZARD CONTROLS (SPR 2-1, 4-1, 4-2)	
1	Workers will be trained to perform tasks safely.
2	Workers will be trained to perform tasks in accordance with standard operating procedures.
3	Workers will wear proper PPE.
4	Workers will be briefed on the hazards of their work area prior to initiating work.

8.8 Elevated Work Hazards

Elevated work hazards relevant to Silo 3 operations include ladders, power lift platforms, and roof/elevated surface access. Portable ladders and power lift platforms may be used to access equipment components for maintenance and repairs. Ladders may be used as a means of temporary entry and exit from an elevated work location. Power lift platforms may be used to access a roof or elevated structure.

NOTE: The SPRs in Table 8-8 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual*.

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TABLE 8-8: ELEVATED WORK HAZARD CONTROLS (SPR 3-6 and 3-4)	
Ladders (SPR 3-6)	
1	Ladders must be inspected before use.
2	Tie off straight ladders or extension ladders when setting them up for use.
3	Portable ladders are inspected at least once each quarter by an individual designated by Fluor Fernald Management as a competent person. An inspection tag identifying the inspector must be affixed to the ladder.
4	Personnel shall not use any ladder that does not have an inspection tag attached.
5	Immediately tag defective ladders DANGER-UNSAFE-DO NOT USE and remove them from service.
6	Do not use ladders where there is a possibility of contact with electrical wiring or energized equipment.
7	Implement fall protection when working at heights of 6 feet or more.
8	Ladders shall not be positioned in front of doorways.
Power Lift Platforms (SPR 3-4)	
1	Only permit-qualified personnel shall operate power lift equipment.
2	Personnel shall establish barricades around the area of operation.

TABLE 8-8: ELEVATED WORK HAZARD CONTROLS (SPR 3-6, 3-4, 2-16)	
3	The operator's manual shall be kept with the equipment and the manufacturer's specifications shall be observed.
4	Equipment inspection shall be conducted per FCP requirements.
5	Hoisting and rigging requirements and electrical safety work practices shall be followed when operating lifts around electrical distribution or transmission lines.
6	Personnel shall not climb out of a lift platform to an elevated work location without a documented evaluation and approval performed by Safety and Health.
Roof/Elevated Surface Access	
1	Before roof or elevated structure access is granted, ensure that an inspection was completed by an Engineer in the past 12 months.
2	After an inspection is performed, or the roof/structure is verified to be on the current inspection list, complete an FCP Work Permit.
3	After all conditions of the Work Permit are met, employees shall be briefed on requirements for access.

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8.9 Hand and Power Tool Hazards

The use of hand and portable power tools present such hazards as cuts and abrasions from unguarded points of operation, eye hazard from flying debris, ergonomic hazard from poor design or improper use, and electrical shock from defective components. Some examples of defective tools are:

- wrenches with sprung jaws that will permit slippage
- mushroomed heads on impact tools such as hammers and chisels
- wooden handles that are loose, cracked, or splintered
- electrical cords that are frayed, cut, or have the ground pin removed
- tools with guards removed
- hydraulic tools with leaking cylinders

NOTE: The SPRs in Table 8-9 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual*.

TABLE 8-9: HAND AND POWER TOOL HAZARD CONTROLS (SPR 4-1)	
1	All hand and power tools shall be maintained in a safe condition.
2	Personnel unfamiliar with power tool operation must be instructed on its operation or read the manufacturer's instructions prior to its use. Manufacturers' operations manuals for power tools can be obtained by contacting the Fluor Fernald supervisor assigning the work.
3	Users shall inspect tools prior to use.
4	Use the equipment as directed in the manufacturer's/owner's safety manual unless an approved plan or procedure specifies using an alternate acceptable method.
5	Ensure guards are in-place and used properly.
6	Tag unsafe or defective equipment with a DANGER-UNSAFE-DO NOT USE tag, remove from service, and notify Leadership/Supervision of its condition.
7	Workers shall not wear loose-fitting clothing, neckties, or jewelry when working with power tools. Watches and wedding rings are acceptable.
8	Power tools shall be stored at assigned locations.
9	Disconnect the power tool from the power source when not being used.
10	Keep electrical cords off the floor and away from possible snagging hazards.

8.10 Electrical Hazards

The use of electrical power is essential to Silo 3 operations. Maintenance and repairs on electrical circuits and other components are Silo 3 maintenance activities that present the highest potential for worker exposure to electrical hazards.

NOTE: The SPRs in Table 8-10 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual.*

TABLE 8-10: ELECTRICAL HAZARD CONTROLS (SPR 5-1)	
1	Only electrically-qualified persons will verify that electrical equipment is suitable for its intended purpose as evidenced by listing, labeling, or certification for that purpose.
2	All electrical equipment shall be operated in accordance with the manufacturer's instructions.
3	Unless specifically exempted by OSHA, a Ground Fault Circuit Interrupter (GFCI) shall be used on each 15- and 20-ampere, 120-volt circuit at the Silos. The GFCI shall be placed at the source of the electrical services to protect both the cord and the devices connected.
4	All electrical appliances shall be Underwriter's Laboratory (UL)-listed for the potential hazards of the atmospheres in which they will be used. Electric tools and equipment (saws, drills, compressors, etc.) will be double-insulated or grounded. All electrical connections shall be made through a GFCI.
5	Fire extinguishers consistent with OSHA 1926.150 [Ref. 49] shall be maintained in sufficient number to allow on-site personnel to extinguish incipient fires.
6	Prior to use, electrical equipment shall be inspected for proper insulation, damage, defects, and operability.
7	Electrical equipment operating at 50 volts or more shall be guarded against accidental contact.
8	On-site electrical equipment shall be bonded and grounded, spark-proof, and explosion-resistant, as appropriate.
9	Electrical equipment shall be de-energized before inspection or maintenance.
10	All electrical tools shall be inspected frequently. Defective tools or questionable tools shall be removed from service and a warning tag applied.

TABLE 8-10: ELECTRICAL HAZARD CONTROLS (SPR 5-1)	
11	Personnel using equipment such as ladders and cranes shall maintain a minimum safe distance of 10 feet from energized overhead lines.
12	Personnel shall wear proper protective equipment in accordance with work permits, safe work plans, or other applicable documents.

8.11 Hazardous Energy

Sources of hazardous energy are present throughout the Silos. Some examples of energy sources include:

- Potential (silo wall post-tensioned reinforcing wires)
- Electrical (throughout the project)
- Radiofrequency (waste package heat sealers)
- Stored (batteries)
- Mechanical (conveyors)
- Hydraulic (remote controlled excavator used for removing material from Silo 3)
- Chemical (to be used in the Waste Additive System)

NOTE: The SPRs in Table 8-11 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual.*

TABLE 8-11: HAZARDOUS ENERGY CONTROLS (SPR 2-11)	
1	Whenever it is necessary to perform maintenance or emergency repairs on hazardous energy systems such as those described above, the hazardous energy system shall be isolated per the OP-0004, *Fluor Fernald Lockout Tagout* [Ref. 50].
2	Personnel who perform hazardous energy isolation shall be trained per the Lockout/Tagout procedure.

8.12 Hoisting and Rigging Hazards

Hoists and rigging may be necessary to repair or replace system components. A bridge crane will routinely lift completed waste packages into Sea/Lands and close the Sea/Land lids.

NOTE: The SPRs in Table 8-12 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual.*

TABLE 8-12: HOISTING AND RIGGING HAZARD CONTROLS (SPR 7-9)

1	The rated capacity shall be permanently marked on the hoist or load block.
2	Hoists shall have labels affixed that display the word "Warning" or other legend to bring the label to the attention of the operator. The label shall contain the cautionary language specified in RM-0045, *Fluor Fernald Hoisting & Rigging Manual* [Ref. 51]
3	Manual-lever-operated hoists shall be equipped with a load-controlling mechanism capable of functioning under normal conditions with test loads up to 125% of rated capacity.
4	Hand chains shall be capable of withstanding, without permanent distortion, a force of three times the pull required to lift the rated load.
5	Web straps shall be made of nylon, polyester, or similar synthetic material.
6	Nylon and polyester web straps shall not be exposed to an ambient temperature >200° F.
7	Electric-powered hoists shall be marked with the voltage of the alternating current (AC) or direct current (DC) power supply and the circuit capacity.
8	Air-powered hoists shall be marked with the rated air pressure.
9	Positive-type safety latches that prevent the hook from opening shall be used.
10	The lift shall be barricaded in a manner that prevents workers from being struck by falling objects.
11	The operator shall inspect hoists and rigging at the beginning of each shift or prior to first use. Inspections shall be performed per RM-0045, *Fluor Fernald Hoisting & Rigging Manual.*
12	All loads shall be centered.

TABLE 8-12: HOISTING AND RIGGING HAZARD CONTROLS (SPR 7-9)	
13	Softeners shall be used to prevent cutting nylon and polyester web straps.
14	If more than 1,000 pounds is supported from a structural steel beam, calculations shall be performed to verify the structural adequacy of the beam.
15	If any load is supported from a concrete beam, calculations shall be performed to verify the structural adequacy of the beam.

8.13 Confined Space Hazards

Confined spaces are evaluated and appropriately posted by Industrial Health & Safety Representatives. The excavator pit, various tanks (including the washwater tanks, additive blend tanks, ferrous sulfate tank, etc.), and electrical manholes are identified as confined spaces.

NOTE: The SPRs in Table 8-13 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual.*

TABLE 8-13: CONFINED SPACE HAZARD CONTROLS (SPR 12-3)	
1	The Industrial Health & Safety Representatives will evaluate the workplace to determine if spaces are permit-required. If permit-required spaces exist, affected personnel shall be informed of their location and their specific dangers. Appropriate signage is shown above.
2	All confined space entry permits shall be performed per the Fluor Fernald Confined Space Entry Program, which can be reviewed by contacting the Silos Industrial Health and Safety Representatives.
3	All workers entering confined spaces shall receive training on confined space entry procedures before performing work.

TABLE 8-13: CONFINED SPACE HAZARD CONTROLS (SPR 12-3)	
4	A person who meets the criteria for designation as a Qualified Person shall evaluate the space. The Qualified Person shall have been trained in confined space entry procedures, supervised field training in the evaluation of confined spaces, and experience in conducting confined space evaluations.
5	An initial hazard assessment will be conducted that includes atmospheric testing for oxygen deficiency, flammable gas concentrations, and toxic gases. No entry shall be permitted if the flammable gas concentration exceeds 10% of the Lower Explosive Limit (LEL).
6	A confined space entry permit will be completed by the Qualified Person and posted at the entrance to the space. Required safety equipment shall be specified on this permit.
7	Before entry, a communication protocol shall be established and reviewed between the persons entering the space and the outside standby personnel.
8	Before entry, a safety meeting will be conducted with all personnel involved with the entry to review all of the hazards and precautions associated with entry.
9	Any person who is to enter a permit-required confined space shall wear a harness and lifeline. A standby person provided with equivalent protection and training for entry in case of an emergency shall man the lifeline.

8.14 Flammable Material Hazards

Flammable materials (e.g., diesel fuel used for heavy equipment, paints used for protective coatings, solvents and thinners) are in use throughout the Silos.

NOTE: The SPRs in Table 8-14 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual.*

TABLE 8-14: FLAMMABLE MATERIAL HAZARD CONTROLS (SPR 11-10)	
1	Sources of ignition are prohibited in areas where flammable materials are present.
2	Flammable material storage locations shall be posted with warning signs Flammable Liquid and No Smoking.

TABLE 8-14: FLAMMABLE MATERIAL HAZARD CONTROLS (SPR 11-10)	
3	On-site equipment shall be bonded and grounded, spark-proof and explosion-resistant, as appropriate. Particular attention to bonding and grounding is given to the transfer of flammable/combustible liquids.
4	For the purposes of fire protection and prevention, persons shall only smoke in designated areas.
5	Portable fire extinguishers are provided in sufficient numbers to allow on-site personnel to extinguish fires. Only personnel trained in the proper use of these fire extinguishers shall use them.

8.15 Hot Work Hazards

Hot work activities (e.g., welding and thermal cutting, grinding) will normally be performed only during maintenance of Silo 3 components, and will not be conducted on a routine basis.

NOTE: The SPRs in Table 8-15 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual*.

TABLE 8-15: HOT WORK HAZARD CONTROLS (SPR 11-7)	
1	Hot work activities will be performed in a manner that provides for the protection of the workers, the public, and the environment. This is accomplished using only trained/qualified persons in the performance of hot work and obtaining an approved Hot Work Permit from Fluor Fernald Fire Protection.

8.16 Compressed Gas Hazards

Compressed gases may be used at the Silos to support maintenance activities. These typically include the oxygen and acetylene cylinders used for hot-work activities.

NOTE: The SPRs in Table 8-16 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual.*

TABLE 8-16: COMPRESSED GAS HAZARD CONTROLS (SPR 8-3)	
1	Prior to handling or using compressed gases, the handler or user shall review the appropriate Material Safety Data Sheet (MSDS) to become knowledgeable of the hazardous properties so that a safe, controlled operation can be maintained.
2	Unless otherwise labeled, compressed gas cylinders shall be considered full and handled accordingly.
3	Cylinders shall be moved by tilting and rolling them on their bottom edges when manually relocating them.
4	Valve protectors shall not be used to lift cylinders from one vertical position to another.
5	When work is finished, when cylinders are empty, or when cylinders are moved at any time, the cylinder valve shall be closed and the cylinder cap installed.
6	Compressed gas cylinders, whether full or empty, shall not be used as rollers, supports, or for any purpose other than the purpose for which they were designed.
7	Suitable cylinder truck, chain, or other steadying device shall be used to prevent cylinders from falling while in use or in storage.
8	Cylinder markings, such as labels and serial numbers, shall not be removed or altered in any way.
9	All empty cylinders must be labeled "Empty."
10	Precautions must be taken to prevent sparks, molten metal, electrical currents, excessive heat, or flames from coming in contact with compressed gas cylinders

TABLE 8-16: COMPRESSED GAS HAZARD CONTROLS (SPR 8-3)	
11	Compressed gas cylinders shall be stored in areas approved for that purpose. Storage areas must be well ventilated and protected from extreme weather conditions to minimize rusting, freezing, continuous exposure to direct sunlight, and contact with the ground. This does not preclude exterior storage.
12	Oxygen cylinders shall be stored a minimum distance of 20 feet from any other fuel gas cylinders or combustible materials (especially oil and grease), or be separated by a non-combustible barrier at least 5 feet high with a fire resistance rating of at least 30 minutes.
13	Compressed gas cylinders shall be secured and stored in an upright position.
14	Never use oil and grease as lubricating agent on valves or attachments to oxygen cylinders.
15	Never locate compressed gas cylinders in an unventilated area.
16	Never attempt to mix gases in a cylinder or use a cylinder for any purpose other than that for which it was intended.
17	Never use oxygen for a substitute for compressed air.
18	Never use an open flame or any other source of ignition to test for cylinder leaks.
19	Cylinders containing oxygen or acetylene or other fuel gases shall not be taken into confined spaces.

8.17 Biological Hazards

Fluor Fernald uses the following controls to protect on-site personnel from the biological hazards associated with Silos project operations.

NOTE: The SPRs in Table 8-17 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual.*

TABLE 8-17: BIOLOGICAL HAZARD CONTROLS (SPR 10-1)	
1	Wild animals (e.g., deer, stray dogs, cats, geese, skunks, raccoons, snakes, and mice) may be encountered at the Silos. On-site personnel are instructed to use discretion and avoid all contact with wild animals. Should these animals present a problem, efforts will be made to trap them and remove them from the site.
2	Insects (e.g., mosquitoes, chiggers, ticks, bees, and wasps) may be found at the site during the warmer months of the year. If insects present a problem, insect sprays will be used to remove them.
3	Poisonous plants (e.g., poison ivy and poison oak) may be encountered at the Silos. Workers will be instructed on how to recognize these plants and to avoid contact with them. When found, these hazards will be removed.

8.18 Environmental Hazards

Extreme ambient temperatures and adverse weather (i.e., high winds, lightning, heavy rains, extreme heat or cold, poor visibility, and hail/ice/snow storms) are hazards that may be encountered at the Silos. Since some of the Silos activities occur outdoors or outside of temperature-controlled environments, control measures must be put in place to protect the workers.

NOTE: The SPRs in Table 8-18 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual.*

TABLE 8-18: ENVIRONMENTAL HAZARD CONTROLS (SPR 2-14)	
1	In the event of adverse weather conditions, the Fluor Fernald S&H Representative will determine if operations may continue without the potential for injury to personnel.
2	Weather-affected work (e.g., work in open locations) shall be stopped if lightning, heavy persistent rain, limited visibility, heavy snow, or other adverse weather conditions are observed in the area of the Silos.
3	Any operation involving the use of cranes, man lifts, or personnel working at heights shall be suspended when wind velocity reaches 25 mph.

8.19 Heat and Cold Stress Hazards

Because maintenance and operations activities are conducted year round, there is the potential for worker exposure to extreme temperatures and the associated heat and cold stress hazards.

Heat stress can present a major hazard at the Silos, especially for workers wearing protective clothing. The same protective materials that shield the body from chemical or radiological exposure also limit the dissipation of body heat and moisture. Therefore, personal protective clothing can create a hazardous condition. Depending on the ambient conditions and the work being performed, heat stress can occur very rapidly (within as little as 15 minutes). Heat stress can pose as great a danger to worker health and safety as chemical exposure.

Cold stress is an important consideration when planning and conducting silo activities during the winter months. Low ambient temperatures can result in health effects ranging from reduced mental alertness and reduction of the ability to make rational decisions to loss of consciousness with the threat of fatal consequences.

NOTE: The SPRs in Table 8-19 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual.*

TABLE 8-19: HEAT AND COLD STRESS HAZARD CONTROLS (SPR 12-9/10)	
1	Fluor Fernald has developed a Heat Stress Program to ensure that on-site personnel are made aware of the signs and symptoms of heat stress and are provided with the appropriate protection against the heat stress hazards. When conditions exist that may present a heat stress hazard, the Industrial Health & Safety Representatives will monitor the work environment and provide controls to protect the work force, such as: • Specified stay time • Access to cool-down areas
2	Fluor Fernald has developed a Cold Stress Program to ensure that on-site personnel are made aware of the signs and symptoms of cold stress. When conditions exist that may present a cold stress hazard, the Silos Industrial Health & Safety Representatives will monitor the work environment and provide controls to protect the work force, such as: • Specified stay times • Heaters • Access to a heated environment

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8.20 Heavy Equipment Hazards

Heavy Equipment will be operated on a routine basis at Silo 3 for transporting and delivering materials and handling shipping conveyances (Sea/Lands).

NOTE: The SPRs in Table 8-20 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual.*

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TABLE 8-20: HEAVY EQUIPMENT HAZARD CONTROLS (SPR 7-2 and 7-7)	
1	Motor vehicle operators must have a Commercial Driver License (CDL) to operate a vehicle weighing 26,001 pounds or greater.
2	When operating vehicles at the FCP, operators must obey all FCP posted speed limits.
3	When operating vehicles at the FCP, operators must obey all FCP traffic safety rules, such as: • Use proper methods of access and egress. • Always keep torsos and extremities within the confines of vehicles. • Wear seat belts at all times. • Never leave an operating vehicle unattended. • Turn on lights between sunset and sunrise prior to operating the vehicle onsite.
4	Vendor vehicles must be loaded and unloaded entirely by vendor employees or entirely by qualified site personnel.
5	Regardless of load content, the vendor and the site are jointly responsible for ensuring that the load is safe and meets all Department of Transportation (DOT) requirements prior to leaving the site.
6	Vehicles are not to be unloaded until the vehicle has been secured by the vendor (i.e., doors or tailgates opened and secured, wheels chocked, etc.)

8.21 Radiological Hazards

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Fluor Fernald Line Management is responsible for ensuring the radiological protection of the workers and environment. The Radiological Control organization provides support personnel, air monitoring, personal sampling, internal and external dosimetry, radiological surveys/monitoring, and job oversight. These activities are implemented through site radiological procedures, Radiation Work Permits (RWPs), and the HPP in Appendix H of this N-HASP.

Potential general occupational radiological hazards for the Silo 3 Project include:

- Airborne Radioactivity (inhalation of radioactive material)
  - Radioactive particulates (alpha from Th-230) generated as a result of the retrieval and packaging activities
  - Radon gas emanating from the Silo 3 material
  - Radon gas potentially emanating from other site sources (e.g., Silos 1 and 2)
- Contamination
  - Skin contamination
  - Injection of radioactive material
  - Spread of contamination to previously-uncontaminated areas
  - Clothing contamination
- External Radiation
  - Radiation exposure from gamma rays generated by the Silo 3 material
  - Gamma radiation from other site sources (AWR Project, Silos 1 and 2)

Airborne Radioactivity

Control of airborne radioactivity is a major objective of the Silo 3 Retrieval and Disposition Project. The most significant radiological hazard associated with Silo 3 material is the inhalation of thorium-230. If a worker received an uptake from Silo 3 material, almost 80 percent of the dose would result from Th-230. Therefore thorium–230 is the isotope of concern. The controls for Silo 3 radiological hazards are presented in **TABLE 8-23**.

Silo 3 residue continually releases radon-222. The total radon inventory in the Silo 3 headspace will be released to the atmosphere under controlled conditions via the exhaust stack. However, the ventilation systems are designed so that very few project operations will be conducted in airborne radioactive areas with radon concentrations exceeding 10 percent of the Derived Air Concentration (DAC), and thus, requiring respiratory protection.

Whenever radiological contamination is an issue, airborne radioactivity is also a concern due to suspension of radioactive contamination (see Contamination section below).

Contamination

The isotope of concern for contamination and airborne radioactivity inside the Silo 3 waste retrieval facility is Th-230. Although the facility was designed to minimize loose surface contamination and airborne radioactivity, some areas will be posted and controlled as Contamination Areas and Airborne Radioactivity areas (for maintenance involving system breaches, the area will be up-posted to a High Contamination Area).

With the following exceptions, the entire Silo 3 waste retrieval facility will initially be posted as an Airborne Radioactivity Area when operations begin. One possible exception is the Cargo Bay Loading Area. Planned exceptions include the Control Room, the Personal Protective Equipment (PPE) Room, and the Control Point Area. These three locations will be maintained as radiologically-controlled areas where loose surface contamination must be kept below 20 disintegrations per minute (dpm)/100 square centimeters (cm^2) (alpha). Another exception is the Additive and Wastewater Tank Area, which is isolated from the Packaging Area by walls and doors. Ventilation in this area is not part of the HEPA/ULPA-filtered ventilation system; it ventilates unfiltered to the outside.

Respiratory protection will be required until adequate documentation has been gathered to prove that the facility design and controls are adequate. However, it is likely that the Excavator Room will always be an Airborne Radioactivity Area.

The Packaging Room, Cargo Bay Loading Area, Vacuum Retrieval Wand, and the remote excavation process are designed to implement an operating philosophy of minimal or no contamination. The highest contamination levels and potential airborne radioactivity hazards are expected:

- in the Excavator Room.
- in the Excavator Service Room when excavator maintenance is being performed.
- whenever a system is breached for maintenance.

An airlock/doffing area is provided for personnel exiting the Excavator Service Room. This area allows workers to doff outer layers of PPE and perform personnel monitoring in an effort to keep contamination/airborne radioactivity levels ALARA in the remainder of the facility. When performing a system breach that potentially involves Silo 3 residues, a High Contamination Area will be set up. Controls will be put in place to prevent the spread of contamination to the remainder of the facility.

External Radiation

Silo 3 material does not present a significant external gamma exposure hazard. However, due to the amount of material to be processed (5,100 yd^3), and the amount of time the workers will spend in the vicinity of the material, external whole-body gamma radiation exposure will be monitored. **TABLE 8-18** shows the anticipated radiation dose rates for selected Silo 3 operator stations. Details on radiation exposure are presented in Appendix D, *Occupational ALARA Analysis for Silo 3*, Table D.8. The Silo 3 dose rates will be measured and documented on the surveys appended to the RWP for entry into the Silo 3 operating areas. PCN2

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TABLE 8-21: ANTICIPATED DOSE RATES AT SELECTED OPERATOR STATIONS (See Appendix D for details on task-specific dose rates)	
Location	**Expected Dose Rate (mR/hr)**
On top of dome performing pneumatic retrieval using vacuum wand	1.9
Remote Operator Station adjacent to the Excavator Room	0.4
Packaging Room	0.4
Cargo Bay Area with full container in area	1.2 at 2.5 ft. 0.3 at 7.5 ft. 4.0 at 1 ft.

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TABLE 8-22 shows the expected operational and maintenance collective doses determined by modeling the Silo 3 systems.

TABLE 8-22: ANTICIPATED COLLECTIVE DOSE FOR SILO 3 OPERATIONS AND MAINTENANCE	
Location	**Expected Collective Dose (person-rem)**
Primary Operations (6 months)	6.25
Primary Maintenance & Inspection (6 months)	0.66
TOTAL OPERATIONS AND MAINTENANCE (this N-HASP)	6.91

Radiological Hazard Controls

As a result of the radiological hazards discussed above, several engineering controls were designed into the system to contain and confine the material, and to handle the material indirectly via specialized equipment. **TABLE 8-23** lists the engineering controls designed into the project to help minimize the exposure potential and help maintain radiation exposures ALARA.

NOTE: The Radiological Control Requirements in Table 8-23 do not comprise the complete list of relevant controls for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable radiological controls, see RM-0020, *Radiological Controls Requirements Manual* [Ref. 52].

TABLE 8-23: RADIOLOGICAL HAZARD CONTROLS	
Engineering Controls	
1	Project ventilation is designed to maintain incoming airflow from Silo 3 and the Process Building negative with respect to atmospheric pressure. Silo 3 and the Process Building have 10,000 CFM of building ventilation, which can assist in the control of airborne radioactivity in the event of leakage. Building ventilation is pulled through a HEPA filter by an exhaust fan and discharged via the 125-foot monitored stack. Both the HEPA assembly and fan are redundant to provide for continuous operation during maintenance and filter changes. The system is set up with pick-up points throughout the building to provide good air changes to eliminate or minimize the build-up of airborne radioactivity. The exhaust stack provides for dispersal of trace radon and any particulates not collected elsewhere within the process ventilation.
2	The Vacuum Wand Management System (VWMS) limits personnel exposures to bulk amounts of waste.
3	Excavation is done remotely. The excavator also includes features such as self-lubricating, camera usage, and interchangeable attachments. Maintenance and inspections are still required.
4	Video cameras provide viewing for the remote excavator. Other cameras will be used to allow for remote viewing of personnel and operations. Cameras will help to reduce the number of individuals and the time required inside the Silo 3 Project work areas.
5	Hoods and enclosures minimize airborne contamination. The Excavator Room hood is positioned near the silo wall opening to capture dust generated during silo wall intrusion.
6	The vacuum wand uses a containment system. The retrieval bin uses a hood to minimize generation of airborne material at the source during mechanical retrieval. The primary and secondary rotary feeders are enclosed and act as airlocks between the relatively-high vacuum of the collector and the ambient pressure of the Feed Conveyor. The Inclined Conveyor is contained within an enclosure.

TABLE 8-23: RADIOLOGICAL HAZARD CONTROLS	
7	Enclosed conveyors contain powders during material movement.
8	Thick PVC bag liners deter radon diffusion and provide containment of silo waste so that completed packages will meet the off-site waste acceptance criteria (WAC).
9	The packaging "bag-out" system controls contamination by providing a heat seal that allows the PVC liner to be severed from the packaging station.
10	Air locks between the Packaging Station Area and the Cargo Bay minimize the spread of contamination.
11	The Silos Project has temporary shielding available, (e.g., lead blankets). However, it is not anticipated that shielding will receive widespread use due to the generally low overall radiation levels that are expected.
12	Particulate air sampling and radon monitoring will be conducted in selected areas in the facility. In addition, Continuous Air Monitors (CAMs) will be used for early indication of elevated particulate airborne radioactivity.
Administrative Controls	
1	Bag-out procedures will be used for the removal of filters from the redundant Process HEPA filter banks (i.e., the stack filters), the Process Vent System, and the building ventilation system to minimize the potential for spread of contamination and generation of airborne radioactivity.
2	Access Controls/Postings/Labeling (see relevant sections in this table)
3	RWPs/Updated Radiological Surveys will be used for: • entry into any radiological area. • breaching of any process line, tank, vessel, or enclosure containing radioactive material that may become loose or airborne during work activities. • any work within the Controlled Area on contaminated or potentially-contaminated equipment where safety precautions are not adequately discussed in Radiological Control-approved technical work documents. • digging or disturbing soil in a Soil Contamination area. • breaching the barrier of a Fixed Contamination Area.
4	Area Radiation/Contamination Monitoring: As part of the Radiological Controls Program, Radiological Control Technicians (RCTs) monitor radiation levels and surface contamination. The Silo 3 Project Radiological Engineer, in conjunction with other safety professionals, determines the required PPE, thermoluminescent dosimeters (TLDs), and any other special radiological precautions. These requirements are controlled and specified on a RWP for each task.

TABLE 8-23: RADIOLOGICAL HAZARD CONTROLS	
5	Area Air Monitoring: Occupational air monitoring for radionuclides will be performed in accordance with RM-0020 [Ref. 52] and the project-specific Occupational Air Monitoring Plan.
6	An ALARA Analysis was completed for Preventative Maintenance Tasks (see Appendix D of this N-HASP).
7	Airborne Radioactivity Areas: If average radon concentrations and airborne particulate levels exceed 10 percent of the DAC, an Airborne Radioactivity Area will be established and appropriate respiratory protection equipment will be established, as prescribed in the RWP for the area/task. Air sampling and/or radon monitoring will continue, as necessary, to determine the extent and duration of the Airborne Radioactivity Area. Airborne Radioactivity areas no longer exceeding 10 percent of the DAC will be down-posted.
8	Completed waste packages will be surveyed before they are placed in the Sea/Lands to determine if there is surface contamination.
Radiological Access Controls: Access to Controlled Areas	
1	Unescorted access to Silos Project Controlled Areas or Radiological Areas requires a minimum of Radiological Worker training.
2	All workers shall be briefed on the contents of each RWP or Safe Work Plan. Workers shall sign an acknowledgment form to signify their understanding of RWP or Safe Work Plan requirements.
3	Before passing the access control point (access point from the uncontrolled area to the controlled area), workers shall check their HAZWOPER Mod 2 training qualification by reviewing their pink card. If their training qualification has expired, they shall contact their supervisor or training coordinator. Radiological Control Dosimetry will provide Exclusion Lists to supervisors of personnel delinquent in bioassay submission.
4	Access into the Silo 3 facility is primarily through the Silo 3 Control Point Trailer (T-205). The primary location for TLD storage is the RCS Operations and Maint. Building (94A).
5	If personnel are assigned TLDs, they shall obtain them before reaching the Controlled Area Workers not assigned TLDs must report to Silos Radiological Control for time-tracking while in the Controlled Areas.
6	Personnel assigned TLDs must wear them while in the Controlled Areas.
7	TLDs shall be worn on the outside of the workers' clothing (non-PPE), facing forward, between their waist and shoulders.

TABLE 8-23: RADIOLOGICAL HAZARD CONTROLS	
8	Visitors may be allowed to enter the Controlled Area upon approval of Radiological Control with a properly trained and cognizant escort.
9	If a worker's training or bioassay is insufficient or out-of-date, access to the controlled area without an escort will be denied.
10	When exiting a Category I Controlled Area, workers shall perform whole body monitoring, (preferably with a personal contamination monitor [PCM]), and monitor personal items with a hand-held frisker.
Radiological Access Controls: Access to Contamination Area	
1	Workers shall sign the appropriate RWP for entry into a contaminated work area.
2	Workers shall obtain the prescribed PPE clothing and respiratory protection equipment, enter their badge number and the respirator serial number into the access control computer, show evidence of being respirator-fit, go to the dressing area, and don the prescribed PPE.
3	When wearing protective clothing so that no skin is exposed (i.e., full anti-Cs and a respirator), the worker's TLD must be worn underneath the protective clothing.
4	When protective clothing requirements allow skin to be exposed (e.g., no respirator), the TLD must be worn on the outside of the anti-Cs.
5	Before entering the Contamination Area, workers shall contact an RCT for assignment of personal air samplers and airflow testing of the powered air-purifying respirators (PAPRs) (if worn). The following conditions apply to persons wearing personal air samplers: • When changing work areas, workers must sign in on the appropriate RWP and verify they are wearing PPE in compliance with the RWP for the new area. If the worker must change PPE before moving to the new job area, the worker must exit the Contamination Area and go through the appropriate steps for re-entry, wearing the correct PPE for the new area. The worker will be assigned a different personal air sampler. • Personal entry into Contamination Areas must be through the established control point.
Exiting Contamination Areas	
1	Whenever their protective clothing is compromised, or when non-water-resistant anti-Cs get wet, or sweat has penetrated protective clothing, workers shall always leave a Contamination Area and doff anti-Cs at the appropriate control point.
2	Workers shall sign out on the RWP upon exiting through the access control point.

TABLE 8-23: RADIOLOGICAL HAZARD CONTROLS	
3	To exit a High Contamination Area inside the Silo 3 facility, the potentially-contaminated outer layer of PPE will be doffed at the High Contamination Area exit (control point). The workers will then perform (at a minimum) hand and foot monitoring with the instrumentation provided by the RCT. Workers must ensure that, when performing monitoring with hand-held alpha friskers, the proper detector distance and frisk rate are used. The proper distance is within one-fourth inch. The proper frisk rate is less than two inches-per-second. The specific monitoring protocol will be determined by the Radiological Engineer and stated on the RWP. If contamination is detected at any control point, the worker will be required to notify an RCT for a response. All equipment and materials to be removed from the Contamination Areas must be surveyed and released by an RCT.
4	After workers exit the Silo 3 facility and doff anti-Cs, whole-body monitoring will be performed in the Silo 3 Control Point Trailer, or other location designated by the RWP, before they proceed to a different work area or leave the Controlled Area.
5	Access to Radiological Areas is controlled by Radiological Control. Workers requiring access to Radiological Areas receive a briefing from an RCT on the area radiological hazards (e.g., contamination levels) and the precautionary measures taken to ensure worker safety (e.g., PPE requirements).
Silo 3 Process Building Radiological Posting	
1	The Silo 3 Process Building will be controlled as a Radiological Area. The specific posting will vary as building conditions change based on activities to be performed. The initial postings for the Silo 3 Process Building will be conservative; they are anticipated to be Airborne Radioactivity Area, Contamination Area, and RWP Required for Entry. If maintenance is to be performed and system breaches are required, the area will be up-posted to a High Contamination Area and a temporary control point will be established (location to be determined by the Radiological Engineer).

TABLE 8-23: RADIOLOGICAL HAZARD CONTROLS	
General Radiological Rules	
1	Eating, drinking, smoking, chewing tobacco or gum, dipping tobacco, and applying make-up are permitted only in areas designated by Radiological Control. Not withstanding the following medical exceptions, at no time are the above activities permitted within Contaminated Areas, High Contamination Areas, or Airborne Radioactivity Areas: • Silos Project personnel receiving medical treatment with radio-pharmaceuticals will be restricted from entering Controlled Areas until the radio-pharmaceutical has cleared sufficiently from his/her system so that frisking with a PCM at the control point does not trigger the alarm. Silos Project personnel who have received treatment with radio-pharmaceuticals must report to Fluor Fernald Medical immediately upon returning to work. • Silos Project personnel who are pregnant may "Declare Pregnancy" per 10 CFR 835, *Occupational Radiation Protection* [Ref. 53]. The pregnant person should report to Fluor Fernald Medical, where she will be informed of the risks related to her pregnancy as a result of working at the Silos Project.

8.22 Chemical Hazards

Potential general occupational chemical hazards include:

- Corrosive materials coming in contact with the skin
- Inhalation of chemical materials
- Chemicals coming in contact with the eyes
- Ingestion of chemicals

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Fluor Fernald S&H personnel are responsible for providing chemical protection support through the use of general area air monitoring, personal sampling, and prescribing PPE. Activities with the potential for chemical exposure of personnel will be governed by work permits, procedures, or task-specific plans, which will also prescribe the level and type of protection to be afforded personnel.

Silo 3 Waste Profile

Twenty-two metals have been identified in the chemical composition of the Silo 3 waste. Analyses performed for the *Remedial Investigation Report for Operable Unit 4* [Ref. 7], and later core samples taken by the project, indicate that the material contains up to 15 percent sulfate and has undergone calcination in temperatures up to 820°C (1,500°F). At this temperature, elements are chemically bonded with their sulfate and oxide compounds. If the sulfate is not stable, it will convert into oxide and sulfur dioxide (a gas). Any volatile organic compounds (VOC) present would have completely decomposed during calcination.

Silo 3 elemental concentrations (mg/kg) are shown in **TABLE 8-24**. These values come from the OU4 Remedial Investigation Report. The concentrations are converted into potentially-releasable inventory (PRI) for comparison to thresholds. The PRI assumes 3,925 tons of Silo 3 material and an estimated damage ratio of 5.5%, which is material release determined for the earthquake silo failure in the Silo 3 ASR [Ref. 16].

Silo 3 waste material contains no compounds listed in 29 CFR 1910.119 [Ref. 31]. Thirteen chemical compounds may be present in inventories exceeding the Reportable Quantities (RQ) values in 40 CFR 302.4 [Ref. 54]

Five compounds exceed Threshold Planning Quantity (TPQ) values established in 40 CFR 355 [Ref. 55] vanadium pentoxide, arsenic trioxide, cadmium oxide, mercuric oxide, and thallium sulfate. Since the preliminary hazard categorization would be driven to HC-3 based on size of inventory alone, the concentrations of arsenic trioxide and vanadium pentoxide are assessed in the accident analyses.

TABLE 8-24: INVENTORY OF INORGANIC CHEMICALS IN SILO 3 MATERIAL

Inorganic Chemical	Concen-tration[a] (mg/kg)	Total Elemental Mass[b] (kg)	Potentially Releasable Inventory[c] (kg)	Table 40 CFR 302.4			40 CFR 355	
				RQ[d] (kg)	Applicable Chemical Compound[e]	Exceed RQ	TPQ[d] (kg)	Exceed TPQ
Aluminum	29,500	105,120	5,782	2,270	Aluminum sulfate	Yes	n.l.	
Arsenic	7,270	25,906	1,425	0.454	Arsenic trioxide	Yes	45.4	Yes
Barium	570	2030	11	Not listed			n.l.	
Beryllium	92	330	2	4.54	Beryllium powder	Yes	n.l.	
Cadmium	343	1,222	67	0.454	Cadmium oxide	Yes	45.4	Yes
Calcium	57,500	204,896	11,269	Not listed			n.l.	
Chromium	823	2933	161	Not listed			n.l.	
Cobalt	6,280	22,378	1,231	Not listed			n.l.	
Copper	7,360	26,227	1,442	4.54	Copper sulfate	Yes	n.l.	
Iron	113,000	402,664	22,147	454	Ferric sulfate	Yes	n.l.	
Lead	6,800	24,231	1,333	4.54	Lead sulfate	Yes	n.l.	
Magnesium	120,000	427,608	23,518	Not listed			n.l.	
Manganese	13,200	47,037	2,587	Not listed			n.l.	
Mercury	1,740	6,200	341	4.54	Mercuric sulfate	Yes	n.l.	
				0.454	Mercuric oxide	Yes	227	Yes
Nickel	9,890	35,242	1,938	45.4	Nickel sulfate	Yes	n.l.	
Potassium	79,200	282,221	15,522	Not listed			n.l.	
Selenium	902	3,214	177	4.54	Selenium dioxide	Yes	n.l.	
Silver	831	2,96s	163	Not listed			n.l.	
Sodium	92,100	328,189	18,050	Not listed			n.l.	
Thallium	163	581	32	45.4	Thallium oxide or sulfate	Yes	45.4	Yes
Vanadium	10,900	38,841	2,136	454	Vanadium pentoxide	No	45.4	Yes
Zinc	849	3025	166	454	Zinc sulfate	No	n.l.	

[a]The 95th percentile concentrations are taken from WSRC-TR-2000-00523, Appendix 3 [Ref. 56].

[b]Total Elemental Mass (kg) = Concentration (mg/kg) x 3,925 tons material x 908 kg/ton x kg/10^6mg

[c]Potentially Releasable Inventory (kg) = Total Elemental Mass x Damage Ratio of 5.5%

[d]RQ is taken from Table 40 CFR 302.4 (Final RQ); TPQ taken from 40 CFR 355, Appendix A

[e]Sulfate or oxide compound assumed based on process chemistry (beryllium powder assumed here for conservatism)

TABLE 8-25 provides the Effective Concentration Limits (ECLs) and hazard rankings for all Silo 3 waste Constituents of Potential Concern (CPCs).

TABLE 8-25: SILO 3 MATERIAL EFFECTIVE CONCENTRATION LIMITS AND HAZARD RANKINGS

Constituent Of Potential Concern (CPC)	Effective Concentration Limit (ECL) (mg/m^3) [1]	Hazard Ranking[2]
Th-230	5E-02	1
Ac-227	3E-01	2
Th-232	6E-01	3
Pa-231	8E-01	4
Arsenic	3E+00	5
Th-228	5E+00	6
Beryllium	7E+00	7
Cobalt	7E+00	8
U-238	1E+01	9
U-234	1E+01	10
Uranium (toxicity)	1E+01	11
Vanadium	1E+01	12
Lead	2E+01	13
Pb-210	2E+01	14
Nickel	2E+01	15
Chromium	3E+01	16
Manganese	4E+01	17
Cadmium	5E+01	18
Calcium	6E+01	19
Ra-226	8E+01	20
Iron	1E+02	21
Aluminum	1E+02	22
Magnesium	1E+02	23
U-235	2E+02	24
Copper	3E+02	25
Silver	6E+02	26
Selenium	9E+02	27
Ra-228	1E+03	28
Thallium	2E+03	29
Barium	2E+03	30
Ra-224	2E+03	31
Mercury	1E+04	32
Zinc	2E+04	33

[1] ECLs are from Table 4 of the *Silo 3 Material Airborne Control Limit Calculation* [Ref. 57].
[2] The ranking is 1 to 33 (most severe inhalation hazard to least severe inhalation hazard)

Top Five Chemical Constituents of Concern

As shown in **TABLE 8-25**, the top five chemical constituents of concern in the Silo 3 material are arsenic, beryllium, cobalt, lead, and chromium (ranked as the 5th, 7th, 8th, 13th, and 16th most severe inhalation hazards, respectively, in the *Silo 3 Material Airborne Control Limit Calculation* [Ref. 58]).

NOTE: The 1st through 5th severe inhalation hazards in Table 8-25 (i.e., Th-230, Ac-227, Th-232, Pa-231) are radiological constituents. Their controls are discussed in Section 8.21.

- Arsenic has been shown to cause skin and lung cancer. It may cause reproduction damage by harming a developing fetus. Contact with the skin can cause irritation, itching, burning, thickening, and color changes. High exposure can cause nausea, vomiting, poor appetite, and muscle cramps. Long-term exposure can cause the formation of an ulcer or hole in the bone dividing the inner nose. High or repeated exposure can cause a 'pins and needles' sensation, burning numbness, and weakness of arms and legs. Repeated exposure can damage the liver and cause stomach problems.

- Beryllium has been shown to cause cancer. Exposure to beryllium may develop into chronic beryllium disease. Permanent scars may develop in the lungs. Symptoms including fatigue, shortness of breath, weight loss, and poor appetite may occur. Beryllium can irritate the nose, throat, and lungs. Bronchitis and/or pneumonia may occur after high exposure to beryllium. Contact with broken skin can cause ulcers and/or lumps to develop. Eye contact can cause irritation, itching, or burning.

- Cobalt may irritate the skin, eyes, nose, and throat. Cobalt may cause coughing and shortness of breath. Higher exposures can cause a build-up of fluid in the lungs called pulmonary edema. Cobalt can cause a skin allergy, with skin rash and itching. It can also cause an asthma-like allergy. If this allergy develops, then future exposures to cobalt can cause shortness of breath, wheezing, coughing, and/or chest tightness. Cobalt can affect the heart, thyroid, and kidneys. Repeated exposure to cobalt dust can cause scarring of the lungs and can be disabling or even fatal. Cobalt may decrease fertility in males.

- Lead can cause headaches, irritability, reduced memory, disturbed sleep, and mood and personality changes. Repeated exposure can lead to lead poisoning. Symptoms include a metallic taste in the mouth, poor appetite, weight loss, colic, upset stomach, nausea, vomiting, and muscle cramps. High or repeated exposure can result in nerve damage, a 'pins and needles' sensation and poor arm and leg coordination. There can be muscle and joint pains and high blood pressure. Lead can cause kidney and brain damage. Lead can damage blood cells, which can lead to anemia. It can take years for the human body to get rid of excess lead. Lead can irritate the eyes, nose, and throat. Lead has been shown to damage animal fetuses, and thus, may also affect human fetuses. Lead may also decrease fertility in men and women.

- Chromium may cause skin and lung allergies. If allergies develop, even low exposures can cause skin rashes, coughing, wheezing or shortness of breath. Exposure to chromium fumes can cause Metal Fume Fever, a flu-like illness involving a metallic taste in the mouth, fever, chills, aches, chest tightness, and cough. This flu-like illness usually lasts for 1-2 days.

Controls specific to the above chemicals are listed in **TABLE 8-26**.

Silo 3 Waste Conditioning Chemicals

The predominant hazardous chemical involved with Silo 3 operations is the ferrous sulfate solution used as an additive in the waste conditioning process (the major Silo 3 hazard is Th-230, a radiological hazard [Section 8.18]). Silo 3 materials will be conditioned with the following chemicals:

- Sodium lignosulfonate (40–weight percent). A polymeric organic binder that will reduce dispersion. The solution is a lignin waste product of pulp and paper processing. Sodium lignosulfonate is not listed in 40 CFR 355 or 40 CFR 302.4. The solution (REAX SN Solution) has a pH range of 8-9. It may cause skin irritation. There is no established exposure criteria for the solution, but breathing mists may irritate the respiratory system. The Cargo Bay inventory is estimated to be approximately 275 gallons.

- Ferrous sulfate (ferrous sulfate heptahydrate, 5% tech iron). An agent for reducing chromium VI to chromium III, which is more amenable to bonding agents [Ref. 57]. The ferrous sulfate solution has a pH of 1.5-3.0. It can damage the skin, eyes, and other mucous membranes. Acute exposure via ingestion can severely impact gastric, digestive, and circulatory systems. Ferrous sulfate is not listed in 40 CFR 355. A 4,500-gallon storage tank is located in the Cargo Container Bay; 4000 gallons will typically be present in the Cargo Bay. This inventory would exceed the 40 CFR 302.4 RQ of 1,000 lb.

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Chemical Hazard Controls

TABLE 8-26 lists the hazard controls designed into the project to help minimize the potential for chemical exposure.

NOTE: The SPRs in Table 8-26 do not comprise the complete list of relevant SPRs for this hazard topic. The items below have been identified as key elements for the Silo 3 Project. For a complete list of applicable SPRs, see the designated SPR section in RM-0021, *Safety Performance Requirements Manual.*

TABLE 8-26: CHEMICAL HAZARD CONTROLS (SPR 2-2, 12-11)	
General Controls	
1	Appropriate PPE will vary based on the location of the employee and the task being performed. PPE requirements will be identified in the work permit and/or procedures.
2	PPE may be upgraded with the appropriate Safety and Health approval authority.
3	If there is a potential to be splashed by a chemical, a faceshield and/or goggles or a full-face respirator will be required to be worn.
4	The Silo 3 facility will be equipped with video cameras to allow for remote viewing of personnel and equipment. This should help to reduce the number of individuals inside the Silo 3 facility and their time inside.
5	Permanent eyewashes are located in the Silo 3 facility. However, if there is a potential for contact with an acidic chemical and the nearest permanent eyewash is more than 100 feet away or it will take more than 10 seconds to reach the eyewash, then a portable eyewash will be located close to the work area.
6	Routine preventative maintenance and inspections will be conducted on all eyewashes.
7	Unescorted access to Silos Project Controlled Areas or Radiological Areas requires a minimum of OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) training.
8	All on-site personnel are required to comply with applicable Fluor Fernald Work Permits, approved work plans, and operational procedures.
9	All workers are briefed on the contents of each work permit, work plan, or operational procedure.

TABLE 8-26: CHEMICAL HAZARD CONTROLS (SPR 2-2, 12-11)	
10	When exiting a Category I Controlled Area, workers shall perform whole body monitoring, preferably with a PCM, and monitor personal material with a hand-held frisker. This procedure should identify any chemical contamination as well as any radiological contamination.
11	Workers shall obtain the prescribed PPE clothing and respiratory protection equipment, enter their badge number and the respirator serial number into the access control computer, show evidence of being respirator-fit, go to the dressing area, and don the prescribed PPE.
12	Workers shall always leave a Contamination Area and doff anti-Cs at the appropriate control point whenever their protective clothing is compromised or when non-water-resistant anti-Cs get wet or workers sweat through their protective clothing. This procedure will prevent contact with, or the spread of, chemical contamination.
13	Eating, drinking, smoking, chewing tobacco or gum, dipping tobacco, and applying makeup are permitted only in areas designated by Fluor Fernald Radiological Control. Except for approved medical exceptions, at no time are these activities permitted within Contaminated Areas, High Contamination Areas, or Airborne Radioactivity Areas. This practice will prevent the ingestion of chemical materials.
14	The design of the Waste Additive System area includes spill control and a flush system.
Arsenic, Beryllium, Cobalt, Lead, and Chromium Controls	
1	The following chemical-specific controls shall be followed in addition to the General Controls listed above.
2	Areas where arsenic, beryllium, cobalt, lead, and chromium are handled will be regulated.
3	Operations involving arsenic, beryllium, cobalt, lead, and chromium will comply with the following controls: • Operations will be enclosed as much as possible. • Exhaust ventilation will be used. • Respirators shall also be worn, as necessary, to ensure that personnel are not exposed to airborne levels that exceed exposure criteria (see Item #4 below). • Personnel handling these constituents shall wear protective gloves and clothing. • If there is skin contact, the area shall be washed. • If vacuuming these materials, a HEPA vacuum shall be used. • Eating, drinking, and smoking shall be prohibited in areas where these constituents are handled.

TABLE 8-26: CHEMICAL HAZARD CONTROLS (SPR 2-2, 12-11)	
4	Exposure to arsenic, beryllium, cobalt, lead, and chromium will be routinely evaluated by collecting personal air samples. Concentrations equaling or exceeding the action levels below will trigger the specified follow-up actions: • Arsenic = 5 micrograms per cubic meter. Follow-up actions per OSHA regulations. • Beryllium = 0.2 micrograms per cubic meter. Although the Silo 3 material does not meet the definition of beryllium found in 10 CFR 850, *Chronic Beryllium Disease Prevention Program* [Ref. 59], protective actions contained in this regulation will be considered as best management practices. • Cobalt = 10 micrograms per cubic meter. Follow-up actions to reduce the generation of cobalt airborne concentrations (e.g., adding ventilation, using wet methods, etc.). • Lead = 30 micrograms per cubic meter. Follow-up actions per OSHA regulations. • Chromium = 0.5 milligrams per cubic meter. Follow-up actions to reduce the generation of chromium airborne concentrations (e.g., adding ventilation, using wet methods, etc.).

9.0 HAZARDS CONTROL MATRIX

A hazards assessment was performed for the tasks assigned to the Fluor maintenance and operations personnel associated with Silo 3 operations (see Section 7.0). The Hazards Control Matrix in **TABLE 9-1** is the method of documenting this assessment. It identifies the tasks to be performed in conjunction with their hazards (as discussed in Section 8.0), and their controls/ mitigators. This matrix forms the basis for employee briefings prior to working on the Silo 3 Project.

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX

Task	Hazard	Mitigators/Controls	Permits/ Guid. Docs
Task 1: Truck transport of empty containers and containerized additive materials	Chemical: Exhaust vapors	• Truck loading/unloading area adequately ventilated to prevented build-up of exhaust vapors • Industrial Hygiene monitoring performed in accordance with site requirements • Trucks not to remain idling for extended periods • Exhaust hoses used, if needed	FCP Work Permit S&H Procedures
	Heavy equipment	• Reflective materials to be worn by ground personnel • Communication to be maintained between truck driver and ground-person when truck in motion • Only qualified drivers permitted to enter and operate within facilities (CDL) • Ground persons not to walk in front of or behind moving trucks • Trucks are not to be left with engines running and unattended • Proper steps to be taken to prevent truck movement during loading operations • Truck drivers to obey site speed limits	Standard Operating Procedure (SOP) SPRs

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 1 (cont.): Truck transport of empty containers and containerized additive materials	Noise	• Hearing Protection to be worn in posted areas	FCP Work Permit S&H Procedures
	Slips, trips, and falls: Slippery surfaces	• Fluids dripping/leaking from trucks absorbed and removed • Liquids collecting on floors to be absorbed and removed	SOP SPRs
	Pinch/crushing points	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Workers will wear proper PPE	SOP Standing Orders FCP Work Permit Pre-job Briefing
	Housekeeping	• Maintain work areas and personnel access-ways free of obstructions and debris	SPR
Task 2: Receipt of Silo 3 bulk chemicals	Chemical	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Industrial Hygiene monitoring, as needed • Workers to wear prescribed PPE • Spill control	FCP Work Permit S&H Procedures MSDS Vendor procedures

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 2 (cont.): Receipt of Silo 3 bulk chemicals	Heavy equipment	• Reflective materials to be worn by ground personnel • Communication to be maintained between truck driver and ground-person when truck in motion • Only qualified drivers permitted to enter and operate within facilities (CDL) • Ground persons not to walk in front of or behind moving trucks • Trucks are not to be left with engines running and unattended • Proper steps to be taken to prevent truck movement during loading operations • Truck drivers to obey site speed limits	SOP SPRs
	Hazardous energy: Static electricity	• Equipment properly grounded prior to chemical delivery	Vendor procedures
	Pinch/crushing points	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Workers will wear proper PPE	SOP Standing Orders FCP Work Permit Pre-job Briefing
	Housekeeping	• Maintain work areas and personnel access-ways free of obstructions and debris	SPR
Task 3: Manipulation of the Pneumatic Retrieval System (PRS) vacuum wand and hose	Illumination	• Work area lighting levels optimal for performing the activity • Industrial Hygiene lighting surveys performed to ensure compliance	HFE SOP Standing Orders S&H Procedures

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 3 (cont.): Manipulation of the Pneumatic Retrieval System (PRS) vacuum wand and hose	Falls	• Fall protection system silo 3 dome	SOP SPRs FCP Work Permit
	Hoisting and rigging: Operating hoist over each manway to assist vacuum wand/hose handling	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures	SOP Pre-job Briefing
	Biological	• On-site personnel are instructed to use discretion and avoid all contact with wild animals. • If insects present a problem, insect sprays will be used to remove them. • Workers will be instructed on how to recognize poisonous plants and to avoid contact with them. When found, these hazards will be removed.	SPR

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 3 (cont.): Manipulation of the Pneumatic Retrieval System (PRS) vacuum wand and hose	Radiological: Airborne radioactivity, contamination, radiation	• Enclosed System to minimize the generation of airborne radioactivity and control the spread of contamination. • Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER/Rad Worker • Workers will use good radiological work practices to prevent the spread of radioactive material and use containments when practical • Protective clothing and equipment will be used as prescribed by Radiological Controls • Work area contamination levels will be kept to a minimum • RCTs will perform contamination surveys to determine work area control levels • RCT oversight • Workers will doff potentially contaminated PPE per posted instructions • Vacuum wand sections to be decontaminated, as needed, when removed from silo penetration	FF RWP ALARA Analysis HPP SOP Pre-job Briefing
	Ergonomics: Lifting/holding/ manipulating wand for extended periods	• Workers will be trained to perform tasks safely • Work durations will be administratively controlled/limited via worker rotation • Mechanical devices (jig) to be used to minimize moment on lower back	HFE SOP Standing Orders Pre-job briefings

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 3 (cont.): Manipulation of the Pneumatic Retrieval System (PRS) vacuum wand and hose	Heat stress Cold stress	• Implementation of the FCP cold/heat stress programs	Pre-job Briefing S&H Procedures SPRs
	Housekeeping	• Maintain work areas and personnel access-ways free of obstructions and debris	SPR
Task 4: Maneuvering of the Mechanical Retrieval System (MRS) remote control vehicle	Illumination	• Work area lighting levels optimal for performing remote operation of excavator • Industrial Hygiene lighting surveys performed to ensure compliance	HFE SOP Standing Orders S&H Procedures
	Radiological: Airborne radioactivity, contamination, radiation	• Remote Operations minimize radiological exposures to the worker • Excavator-mounted misting system can be used to suppress dust during excavation • Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER/Rad Worker • Protective clothing and equipment will be used as prescribed by Radiological Controls • Work area contamination levels will be kept to a minimum • RCTs will perform contamination surveys to determine work area control levels • RCT oversight	FF RWP ALARA Analysis HPP SOP Pre-job Briefing

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 4 (cont.): Maneuvering of the Mechanical Retrieval System (MRS) remote control vehicle	Noise	• Wear hearing protection if required by area posting	Pre-job Briefing S&H Procedures
	Ergonomics: Carpal tunnel syndrome	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures	HFE
	Hazardous energy: Electrical	• Cable mgmt system (take-up reel)	Vendor procedures
	Hazardous energy: Remotely-operated equipment	• MRS designed and built to standards • MRS undergoes acceptance reviews • Workers will be trained on equipment to perform tasks safely	Design specs. SOP
	Pinch/crushing points	• MRS designed and built to standards • MRS undergoes acceptance reviews • Workers will be trained on equipment to perform tasks safely	Design specs. SOP
	Housekeeping	• Maintain work areas and personnel access-ways free of obstructions and debris	SPR

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 5: Conditioning and packaging of retrieved waste	Chemical: Acid vapors/splash during chemical addition	• Industrial Hygiene monitoring of work area • Chemical addition components working within design parameters • Workers performing tasks as trained	S&H Procedures SOPs
	Illumination	• Work area lighting levels optimal for performing the activity • Industrial Hygiene lighting surveys performed to ensure compliance	HFE SOP Standing Orders S&H Procedures

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 5 (cont.): Conditioning and packaging of retrieved waste	Radiological: Airborne radioactivity, contamination, radiation	• Most of the activity is performed remotely to minimize radiological exposures to the worker • A thick liner is used for the packaging to minimize radon emanation and the potential for breaching the package during filling and handling • Heat seal for containment during bag separation • Liner seals to mixer chute using remotely inflatable boots to maintain containment. • Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER/Rad Worker • Workers will use good radiological work practices to prevent the spread of radioactive material and use containments when practical • Protective clothing and equipment will be used as prescribed by Radiological Controls • Work area contamination levels will be kept to a minimum • RCTs will perform contamination surveys to determine work area control levels • RCT oversight • Workers will doff potentially contaminated PPE per posted instructions	FF RWP ALARA Analysis HPP SOP Pre-job Briefing

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 5 (cont.): Conditioning and packaging of retrieved waste	Ergonomics: Overhead reaching	• Work durations will be administratively controlled/limited via worker rotation • Workers will be trained to perform tasks safely	HFE SOPs Standing Orders Pre-job Briefing
	Pinch/crushing points	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Workers will wear proper PPE • Workers will not place hands, head or feet between lid and container, container and conveyor, or container and container. • Workers to be briefed on the hazards of their work area prior to initiating packaging activities	SOP Standing Orders FCP Work Permit Pre-job Briefing
	Head impact: Falling objects	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Workers are never to position their bodies under a load • Only Qualified personnel will operate the hoist • Head protection will be worn by personnel when the potential for falling objects or head injuries due to impact exist.	SOP Standing Orders FCP Work Permit Pre-job Briefing
	Ergonomics: Lifting (waste package liners)	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures	SPR 2-5 SOP Pre-job Briefing

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 5 (cont.): Conditioning and packaging of retrieved waste	Waste package heat sealer/bag cutter	• Workers will be trained to perform tasks safely	Vendor procedures Pre-job Briefing
	Hoisting and rigging: Lifting full bags	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures	SOP Pre-job Briefing
	Hand and power tools: Strapping down load	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures	SOP Vendor procedures
	Housekeeping	• Maintain work areas and personnel access-ways free of obstructions and debris	SPR
Task 6: Loading of containerized material	Head impact: Falling objects	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Workers are never to position their bodies under a load • Only Qualified personnel will operate the hoist • Head protection will be worn by personnel when the potential for falling objects or head injuries due to impact exist.	SOP Standing Orders FCP Work Permit Pre-job Briefing

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 6 (cont.): Loading of containerized material	Heavy equipment	• Reflective materials to be worn by ground personnel • Communication to be maintained between truck driver and ground-person when truck in motion • Only qualified drivers permitted to enter and operate within facilities (CDL) • Ground persons not to walk in front of or behind moving trucks • Trucks are not to be left with engines running and unattended • Proper steps to be taken to prevent truck movement during loading operations • Truck drivers to obey site speed limits	SOP SPRs
	Hoisting and rigging: Removing cargo lid; lifting packages into Sea/Land; replacing lid	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Only Qualified personnel will operate the hoist	SOP Pre-job Briefing
	Ladders and climbing: Removing the rigging from packages in the Sea/Land	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Workers are never to position their bodies under a load • Only Qualified personnel will operate the hoist	SOP Pre-job Briefing

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 6 (cont.): Loading of containerized material	Pinch/crushing points	• Packaging equipment designed and built to standards. • Equipment undergoes acceptance reviews • Workers will be trained on equipment to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Workers will wear proper PPE • Workers will not place hands, head or feet between lid and container, container and conveyor, or container and container. • Workers to be briefed on the hazards of their work area prior to initiating loading activities	Design specs. SOP Standing Orders FCP Work Permit Pre-job Briefing
	Illumination	• Work area lighting levels optimal for performing the activity • Industrial Hygiene lighting surveys performed to ensure compliance	HFE SOP Standing Orders S&H Procedures

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 6 (cont.): Loading of containerized material	Radiological: Airborne radioactivity, contamination, radiation	• Use of a conveyor system, rigging, and fork trucks to minimize handling • Radiological survey to minimize the potential for the spread of contamination • Placement of several packages in a single Sea/Land to minimize labeling and other transportation handling requirements (e.g., labeling/stenciling) • Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER/Rad Worker • Protective clothing and equipment will be used if prescribed by Radiological Controls • RCTs will perform area contamination surveys to determine work area control levels • Completed packages will be surveyed for surface contamination before loading • Air locks between the Packaging Station Area and the Cargo Bay minimize the spread of contamination • RCT oversight	FF RWP ALARA Analysis HPP SOP Pre-job Briefing

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 6 (cont.): Loading of containerized material	Chemical: Exhaust vapors	• Fork truck loading/unloading area adequately ventilated to prevented build-up of exhaust vapors • Industrial Hygiene monitoring performed in accordance with site requirements • Fork trucks not to remain idling for extended periods • Exhaust hoses used, if needed	FCP Work Permit S&H Procedures
	Hazardous energy: Remotely-controlled equipment	• Packaging equipment designed and built to standards. • Equipment undergoes acceptance reviews • Workers will be trained on equipment to perform tasks safely	Design specs. SOP
Task 7: On-site Transportation of Containerized Waste Materials	Heavy equipment	• Operators must obey all FCP posted speed limits • Operators must obey all FCP traffic safety rules	SPR 7 - 3 Qualified Operators
	Radiological: Airborne radioactivity, contamination, radiation	• Loaded radiological surveys of completed shipments • Placement of packages in a Sea/Land container • Staging of completed shipments and use of placarding/ Radiological postings • Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER/Rad Worker if necessary • RCT oversight	FF RWP ALARA Analysis HPP SOP Pre-job Briefing
	Housekeeping	• Maintain work areas and personnel access-ways free of obstructions and debris	SPR

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 8: Maintenance of the Pneumatic Retrieval System (PRS), Air Handling Systems, and Process Vent System	Radiological: Airborne radioactivity, contamination, radiation	• Workers will use good radiological work practices to prevent the spread of radioactive material and use containments/HEPA ventilation when practical • As necessary, decontamination prior to performing maintenance • Capable of using bag-out process for removal of HEPA-ULPA (ultra-low penetrating air) filters and pre-filters, and cartridges and bags • Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER/Rad Worker • Protective clothing and equipment will be used as prescribed by Radiological Controls • Work area contamination levels will be kept to a minimum • RCTs will perform contamination surveys to determine work area control levels • RCT oversight • Workers will doff potentially contaminated PPE per posted instructions	FF RWP ALARA Analysis HPP SOP Pre-job Briefing

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX

Task	Hazard	Mitigators/Controls	Permits/ Guid. Docs
Task 8 (cont.): Maintenance of the Pneumatic Retrieval System (PRS), Air Handling Systems, and Process Vent System	Confined spaces	• Confined Space Entry procedures • Confined Space Training • Proper labeling of Confined Spaces	SOP Pre-job Briefing FCP Work Permit Confined Space Entry Permit
	Hazardous energy: Electrical shock/ inadvertent equipment start-up	• Energy isolation will be performed per site procedures • Only trained personnel will perform work on locked-out/tagged-out equipment	Energy Isolation Plan (EIP)/SOP
	Chemical	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPERs • Industrial Hygiene monitoring, as needed • Workers to wear prescribed PPE • Follow the directions outlined in the MSDS for handling cleaners, lubricants, etc. • Supervision must ensure that workers have been briefed, as necessary, on MSDS's	FCP Work Permit S&H Procedures MSDS
	Illumination	• Work area lighting levels optimal for performing the activity • Industrial Hygiene lighting surveys performed to ensure compliance	HFE SOP Standing Orders S&H Procedures

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX

Task	Hazard	Mitigators/Controls	Permits/ Guid. Docs
Task 8 (cont.): Maintenance of the Pneumatic Retrieval System (PRS), Air Handling Systems, and Process Vent System	Flammable material	• Workers will be trained in fire protection and prevention.	SOP SPR
	Compressed gas	• Workers will be trained in the safe use of compressed gas cylinders.	SPR
	Hand and power tools	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures	SOP Vendor procedures
	Pinch/crushing points	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Workers will wear proper PPE	SOP Standing Orders FCP Work Permit Pre-job Briefing
	Head impact	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Head protection will be worn by personnel when the potential for falling objects or head injuries due to impact exist.	FCP Work Permit SOP Pre-job briefing
	Housekeeping	• Maintain work areas and personnel access-ways free of obstructions and debris	SPR

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 9: Maintenance of motorized vehicles (including the MRS)	Hazardous energy: Electrical shock/ inadvertent equipment start-up	• Energy isolation will be performed per site procedures • Only trained personnel will perform work on locked-out/tagged-out equipment • Cable-mgmt system (take-up reel)	EIP/SOP
	Hot surfaces	• Equipment cooled down prior to performing work • Proper use of PPE • Only qualified personnel to perform work	SOP Pre-job Briefing
	Flammable material	• Workers will be trained in fire protection and prevention.	SOP SPR
	Compressed gas	• Workers will be trained in the safe use of compressed gas cylinders.	SPR
	Pinch/crushing points	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Workers will wear proper PPE	SOP Standing Orders FCP Work Permit Pre-job Briefing
	Illumination	• Work area lighting levels optimal for performing the activity • Industrial Hygiene lighting surveys performed to ensure compliance	HFE SOP Standing Orders S&H Procedures

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX

Task	Hazard	Mitigators/Controls	Permits/ Guid. Docs
Task 9 (cont.): Maintenance of motorized vehicles (including the MRS)	For MRS: Radiological (airborne radioactivity, contamination, radiation)	• Workers will use good radiological work practices to prevent the spread of radioactive material and use containments/HEPA ventilation when practical • As necessary, decontamination prior to performing maintenance • Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER/Rad Worker • Protective clothing and equipment will be used as prescribed by Radiological Controls • Work area contamination levels will be kept to a minimum • RCTs will perform contamination surveys to determine work area control levels • RCT oversight • Workers will doff potentially contaminated PPE per posted instructions	FF RWP ALARA Analysis HPP SOP Pre-job Briefing
	Chemical	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER • Industrial Hygiene monitoring, as needed • Workers to wear prescribed PPE • Follow the directions outlined in the MSDS for handling cleaners, lubricants, etc. • Supervision must ensure that workers have been briefed, as necessary, on MSDSs	FCP Work Permit S&H Procedures MSDS

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 9 (cont.): Maintenance of motorized vehicles (including the MRS)	Hand and power tools	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures	SOP Vendor procedures
	Head impact	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Head protection will be worn by personnel when the potential for falling objects or head injuries due to impact exist.	FCP Work Permit SOP Pre-job briefing
	Housekeeping	• Maintain work areas and personnel access-ways free of obstructions and debris	SPR
Task 10: Maintenance of conveyors, feeders, and packagers	Hazardous Energy: Electrical shock/ inadvertent equipment start-up	• Energy isolation will be performed per site procedures • Only trained personnel will perform work on locked-out/tagged-out equipment	EIP/SOP
	Flammable material	• Workers will be trained in fire protection and prevention.	SOP SPR
	Compressed gas	• Workers will be trained in the safe use of compressed gas cylinders.	SPR
	Elevated work surfaces	• Fall protection system used by workers	SOP SPRs FCP Work Permit
	Hand and power tools	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures	SOP Vendor procedures

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 10 (cont.): Maintenance of conveyors, feeders, and packagers	Pinch/crushing points	• Equipment designed and built to standards • Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Workers will wear proper PPE	SOP Standing Orders FCP Work Permit Pre-job Briefing
	Confined spaces: Entering the pit to work on the feed bin screws and/or incline conveyor	• Confined Space Entry procedures • Confined Space Training • Proper labeling of Confined Spaces	SOP Pre-job Briefing FCP Work Permit Confined Space Entry Permit
	Illumination	• Work area lighting levels optimal for performing the activity • Industrial Hygiene lighting surveys performed to ensure compliance	HFE SOP Standing Orders S&H Procedures

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 10 (cont.): Maintenance of conveyors, feeders, and packagers	Radiological: Airborne radioactivity, contamination, radiation	• Workers will use good radiological work practices to prevent the spread of radioactive material and use containments/HEPA ventilation when practical • As necessary, decontamination prior to performing maintenance • Use of HEPA ventilation to minimize airborne radioactivity • Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER/Rad Worker • Protective clothing and equipment will be used as prescribed by Radiological Controls • Work area contamination levels will be kept to a minimum • RCTs will perform contamination surveys to determine work area control levels • RCT oversight • Workers will doff potentially contaminated PPE per posted instructions	FF RWP ALARA Analysis HPP SOP Pre-job Briefing

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 10 (cont.): Maintenance of conveyors, feeders, and packagers	Chemical	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER • Industrial Hygiene monitoring, as needed • Workers to wear prescribed PPE • Follow the directions outlined in the MSDS for handling cleaners, lubricants, etc. • Supervision must ensure that workers have been briefed, as necessary, on MSDSs	FCP Work Permit S&H Procedures MSDS
	Confined space	• Confined Space Entry procedures • Confined Space Training • Proper labeling of Confined Spaces	SOP Pre-job Briefing FCP Work Permit Confined Space Entry Permit
	Heat stress	• Controlled stay times • Implementation of Heat Stress Program	SOPs SPR 12-10 Pre-job Briefing
	Head impact	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Head protection will be worn by personnel when the potential for falling objects or head injuries due to impact exist.	FCP Work Permit SOP Pre-job briefing

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 10 (cont.): Maintenance of conveyors, feeders, and packagers	Housekeeping	• Maintain work areas and personnel access-ways free of obstructions and debris	SPR
Task 11: Maintenance of cranes	Hazardous energy: Electrical shock/ inadvertent equipment start-up	• Energy isolation will be performed per site procedures • Only trained personnel will perform work on locked-out/tagged-out equipment	EIP/SOP
	Flammable material	• Workers will be trained in fire protection and prevention.	SOP SPR
	Compressed gas	• Workers will be trained in the safe use of compressed gas cylinders.	SPR
	Elevated work surfaces	• Fall protection system used by workers	SOP SPRs FCP Work Permit
	Pinch/crushing points	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Workers will wear proper PPE	SOP Standing Orders FCP Work Permit Pre-job Briefing
	Head impact	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Head protection will be worn by personnel when the potential for falling objects or head injuries due to impact exist.	FCP Work Permit SOP Pre-job briefing

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 11 (cont.): Maintenance of cranes	Illumination	• Work area lighting levels optimal for performing the activity • Industrial Hygiene lighting surveys performed to ensure compliance	HFE SOP Standing Orders S&H Procedures
	Housekeeping	• Maintain work areas and personnel access-ways free of obstructions and debris	SPR
Task 12: Maintenance of Waste Additive System and Wastewater System	Confined spaces	• Confined Space Entry procedures • Confined Space Training • Proper labeling of Confined Spaces	SOP Pre-job Briefing FCP Work Permit Confined Space Entry Permit

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 12 (cont.): Maintenance of Waste Additive System and Wastewater System	Waste Water System: Radiological (airborne radioactivity, contamination, radiation)	• Flushing of system prior to working on system • Use of HEPA ventilation to minimize airborne radioactivity • Workers will use good radiological work practices to prevent the spread of radioactive material and use containments/HEPA ventilation when practical • As necessary, decontamination prior to performing maintenance • Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER/Rad Worker • Protective clothing and equipment will be used as prescribed by Radiological Controls • Work area contamination levels will be kept to a minimum • RCTs will perform contamination surveys to determine work area control levels • RCT oversight • Workers will doff potentially contaminated PPE per posted instructions	FF RWP ALARA Analysis HPP SOP Pre-job Briefing

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 12 (cont.): Maintenance of Waste Additive System and Wastewater System	Chemical	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER • Industrial Hygiene monitoring, as needed • Workers to wear prescribed PPE • Follow the directions outlined in the MSDS for handling cleaners, lubricants, etc. • Supervision must ensure that workers have been briefed, as necessary, on MSDSs	FCP Work Permit S&H Procedures MSDS
	Hazardous energy: Electrical shock/ inadvertent equipment start-up	• Energy isolation will be performed per site procedures • Only trained personnel will perform work on locked-out/tagged-out equipment	EIP/SOP
	Flammable material	• Workers will be trained in fire protection and prevention.	SOP SPR
	Compressed gas	• Workers will be trained in the safe use of compressed gas cylinders.	SPR
	Hand and power tools	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures	SOP Vendor procedures
	Pinch/crushing points	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Workers will wear proper PPE	SOP Standing Orders FCP Work Permit Pre-job Briefing

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 12 (cont.): Maintenance of Waste Additive System and Wastewater System	Head impact	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Head protection will be worn by personnel when the potential for falling objects or head injuries due to impact exist.	FCP Work Permit SOP Pre-job briefing
	Illumination	• Work area lighting levels optimal for performing the activity • Industrial Hygiene lighting surveys performed to ensure compliance	HFE SOP Standing Orders S&H Procedures
	Housekeeping	• Maintain work areas and personnel access-ways free of obstructions and debris	SPR
Task 13: Maintenance of Plant/Breathing Air System	Hazardous energy: Electrical shock/ inadvertent equipment start-up	• Energy isolation will be performed per site procedures • Only trained personnel will perform work on locked-out/tagged-out equipment	EIP/SOP
	Flammable material	• Workers will be trained in fire protection and prevention.	SOP SPR
	Compressed gas	• Workers will be trained in the safe use of compressed gas cylinders.	SPR
	Pinch/crushing points	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Workers will wear proper PPE	SOP Standing Orders FCP Work Permit Pre-job Briefing

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 13 (cont.): Maintenance of Plant/Breathing Air System	Head impact	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Head protection will be worn by personnel when the potential for falling objects or head injuries due to impact exist.	FCP Work Permit SOP Pre-job briefing
	Illumination	• Work area lighting levels optimal for performing the activity • Industrial Hygiene lighting surveys performed to ensure compliance	HFE SOP Standing Orders S&H Procedures
	Housekeeping	• Maintain work areas and personnel access-ways free of obstructions and debris	SPR
Task 14: Shift-by-shift surveillance of Silo 3	Noise	• Wear hearing protection if required by area posting	Pre-job Briefing S&H Procedures

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 14 (cont.): Shift-by-shift surveillance of Silo 3	Radiological: Airborne radioactivity, contamination, radiation	• Use of remote cameras and windows • Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER/Rad Worker • Protective clothing and equipment will be used as prescribed by Radiological Controls • Work area contamination levels will be kept to a minimum • RCTs will perform contamination surveys to determine work area control levels • RCT oversight • Workers will doff potentially contaminated PPE per posted instructions	FF RWP ALARA Analysis HPP SOP Pre-job Briefing
	Chemical	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with procedures • Workers will qualify as 40-hr HAZWOPER • Industrial Hygiene monitoring, as needed • Workers to wear prescribed PPE • Follow the directions outlined in the MSDS for handling cleaners, lubricants, etc. • Supervision must ensure that workers have been briefed, as necessary, on MSDSs	FCP Work Permit S&H Procedures MSDS

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 14 (cont.): Shift-by-shift surveillance of Silo 3	Slips, trips, and falls	• Good housekeeping practices will be followed by all personnel • Area lighting will be adequate for the type of work to be performed • If possible, avoid walking on uneven surfaces • Observe work area tripping hazards when coming to and leaving the area • Carefully place feet on stairs when ascending or descending stairway. • Always use handrails when ascending or descending stairway • Always maintain 3-points of contact when ascending/descending stairways	Briefings Walk-throughs Engineering design
	Heat stress Cold stress	• Implementation of the FCP cold/heat stress programs	Pre-job Briefing S&H Procedures SPRs
	Housekeeping	• Maintain work areas and personnel access-ways free of obstructions and debris	SPR
	Ladders and climbing	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures	SPRs

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 14 (cont.): Shift-by-shift surveillance of Silo 3	Head impact	• Workers will be trained to perform tasks safely • Workers will perform tasks in accordance with standard operating procedures • Head protection will be worn by personnel when the potential for falling objects or head injuries due to impact exist.	SPR
	Biological	• On-site personnel are instructed to use discretion and avoid all contact with wild animals. • If insects present a problem, insect sprays will be used to remove them. • Workers will be instructed on how to recognize poisonous plants and to avoid contact with them. When found, these hazards will be removed.	SPR
	Environmental	• In the event of adverse weather conditions, the Fluor Fernald S&H Representative will determine if operations may continue without the potential for injury to personnel.	SPR
	Illumination	• Work area lighting levels optimal for performing remote operation of excavator • Industrial Hygiene lighting surveys performed to ensure compliance	HFE SOP Standing Orders S&H Procedures

TABLE 9-1: SILO 3 HAZARDS CONTROL MATRIX			
Task	**Hazard**	**Mitigators/Controls**	**Permits/ Guid. Docs**
Task 15: Cutting a Hole in the Silo 3 Wall Structure	See the Silos Construction HASP	Hole cutting is a construction activity performed by construction labor. The associated hazards and their controls/mitigators are addressed in Silos Construction HASP [Ref. 38]. The Silo 4 mock access demonstration was performed during the construction of the retrieval facility. However, Silo 3 wall access will occur after the operations phase has begun because the plan calls for pneumatic retrieval of material behind the intended wall opening. Therefore, there will be a short window of time when operations (authorized by this N-HASP) and construction work will overlap.	See the Silos Const. HASP

10.0 SYSTEM SAFETY REQUIREMENTS

System Safety Requirements are used to ensure project activities are maintained within the current safety envelope. The System Safety Requirements may be Safety Basis Requirements (SBRs) or Process Requirements (PRs), depending on the relative risk associated with each requirement. The following definitions apply:

- **SBRs** – A limitation for a facility, operation, or activity which is directly associated with its analyzed safety envelope and current hazard categorization or classification. Some examples of SBRs include:

  - In nuclear facilities with a SAR or a Hazard Analysis Report (HAR), the SBRs may be termed TSRs and are subject to 10 CFR 830 Subpart B.

  - Inventory threshold limits and/or dose limits established in a safety basis document. Each nuclear facility Basis for Interim Operations (BIO) states threshold limits.

  - Limitations on material types, characteristics, and unique properties, such as, pyrophoricity, corrosiveness, toxicity, reactivity, flammability, etc., as specified in the analysis.

  - Nuclear criticality safety requirements related to the direct prevention of a criticality, i.e., maintaining compliance with the double contingency principle is an SBR.

- **PRs** – PRs are developed and implemented to help ensure that SBRs are not exceeded or otherwise violated. Both SBRs and PRs establish requirements that the project must implement to ensure adequate defense-in-depth.

Silo 3 Retrieval and Disposition has been determined to qualify as a RAD Facility based on the analyses discussed in Appendix B, *Hazard Category Calculation*. Although Silo 3 Retrieval and Disposition qualifies as nuclear HC-3 based on inventory, it qualifies as RAD based on analytical consequences. Per DOE-STD-1120-98, *Integration of Environment, Safety and Health into Facility Disposition Activities* [Ref. 5], a RAD categorization/classification based on analytical consequences requires DOE approval. To provide defense-in-depth, Section 10.2 specifies System Safety.

10.1 Violation of System Safety Requirements

The requirements established by the FCP Safety Programs are relied upon to ensure that Silo 3 operations are conducted safely. Several support programs, such as the QA Program and the CONOPS Program, are relied upon to ensure that the elements of the FCP Safety Program are met. The maintenance of each of the safety programs is addressed within the associated program requirements manuals. In general, violations of FCP Safety Program requirements are addressed using QA-0001, *Fluor Fernald Nonconformance Identification and Tracking System* [Ref. 60]. The remaining discussion within this section establishes the actions to be taken following a violation of the specific requirements (i.e., SBRs and PRs).

Both SBRs and PRs establish requirements which ensure adequate defense-in-depth. Violation of an SBR or PR is subject to the requirements of SH-1006, *Event Investigation and Reporting* [Ref. 61], because a violation has a potential to degrade the Safety Basis. In the case of PRs, the requirement shall be evaluated to determine the impact to the defined SBR(s). In all cases, discovery of a violation results in appropriate notifications and an evaluation of impacts to the Safety Basis.

NOTE: Because the silos themselves are HC-3 facilities, when a potential SBR/PR violation could affect the Silos, the potential violation will be evaluated using the Safety Analysis Evaluation Process in Addendum 2 of PL-3049, *Implementation Plan for SARs and TSRs at the FEMP* [Ref. 62]. SBR/PR violations that affect the Silos are subject to the USQ process per NS-0002, *Unreviewed Safety Question (USQ) Determination and Safety Evaluation System* (USQD/SE System) [Ref. 45]. See also Section 10.3, Silos Project TSR.

Overview of the Potential Violation Response

A Silo 3 system safety SBR or PR violation occurs when there is a noncompliance with the requirement(s) listed in Section 10.2, Table 10.1. If there is a deviation from a system safety SBR or PR, activities will be placed in a safe configuration and the Assistant Emergency Duty Officer (AEDO), Silos Project management, and the RCS Control Room contacted. No further actions shall be taken until N&SS has evaluated the deviation to determine whether the project is outside the project safety envelope.

Following notification of a potential violation, project management may determine to temporarily limit the affected activities until the evaluation is completed. This limitation is defined as the "standby" mode of operations and allows time to adequately evaluate the impact of violating the requirements and to initiate corrective actions. A standby operating mode does not constitute a facility shutdown resulting from operations outside the approved Safety Basis and will not automatically require re-start authority per QA-0021, *Administration and Conduct of Standard Startup Review (SSR) Activities* [Ref. 63], to resume operations.

Once activities have been halted, N&SS personnel shall make a determination if operations have been conducted outside the Safety Basis. Operations determined to be outside the Safety Basis require a formal facility shutdown, corrective action, and restart approval. DOE-FCP has delegated to Fluor Fernald the approval authority for safety documentation and the startup and restart of Radiological and Other Industrial Facilities at the FCP [Ref. 64]. If the violation results in exceeding the delegated authority granted by DOE-FCP (e.g., hazard category greater than RAD), then the USQD/SE process shall be initiated.

10.2 Silo 3 System Safety Requirements

The matrix in **TABLE 10-1** has been developed to identify Silo 3 System Safety Requirements, reference the origin of the requirements, and identify the method(s) of control and implementing document(s), as appropriate. These System Safety Requirements are provided for Defense-in-Depth. Table 10-1 is the requirements matrix pursuant to the DOE-approved *Decision Basis Document Implementation of 10 CFR 830 Safe Harbor Requirements for the Silos Projects,* 40000-RP-0034 [Ref. 1]. Table 10.1 identifies the requirements of the written site safety and health program and project specific requirements that relate to system safety and are relied upon for maintaining the safety envelope.

As identified in Appendix G, *Silo 3 Accident Analysis*, there are no safety class or safety-significant components associated with the Silo 3 Retrieval and Disposition Project. This is based on the fact that Silo 3-initiated accident scenarios do not yield consequences that would exceed on-site dose limits, nor was any mitigation credit taken for these systems, structures, and components in the consequence analysis. However, SBRs and PRs were developed around some components to provide defense-in-depth.

TABLE 10-1: SILO 3 SYSTEM SAFETY REQUIREMENTS

SBR, PR	Requirement	Basis/Source	Implementation
SBR-1	Wall cutting activity, for mechanical retrieval, must be authorized by updated documentation, including but not limited to an Unreviewed Safety Question Determination (USQD) and Operations Work Instructions.	Although consequences are analyzed in this document as EBA-2 (see Appendix G), the wall cutting activity is authorized in the Silo 3 PHAR [Ref. 14] and the work will be done by Construction.	• NS-0002 • Management assessment
PR-1	The Silo 3 stack monitoring capability will be maintained within defined operability parameters, with established action level thresholds and operating limits. Operating data from the particulate filtering system (i.e., pressure differential) can be relied upon during maintenance events on the stacks samplers.	Public and Worker Protection, Environmental Protection Agency (EPA) Required	• 40000-PL-012, *Silos Engineering Project Execution Plan* (i.e. Silos Design Change Notice) • Operations procedures • Routine calibration and maintenance • Routine inspections • Engineering design

TABLE 10-1: SILO 3 SYSTEM SAFETY REQUIREMENTS			
SBR, PR	**Requirement**	**Basis/Source**	**Implementation**
PR-2	Individual IP-2 bulk bags shall not exceed 7000 lbs. gross weight.	EBA-4 (App. G) Test Report for IP-2 Container Testing [Ref. 65]	• Operations procedures • Routine inspections • Engineering design • Routine calibration and maintenance
PR-3	Verify that IP-2 bulk bags/packages are sealed before transfer outside of the Cargo Bay area.	Shipping requirement	• Operations procedures • Routine inspections • Engineering design • Routine calibration and maintenance
PR-4	Visually inspect the flexible fabric boot on each vacuum wand for verification of integrity (i.e. in place, no holes).	Public and Worker Protection, Containment	• Operations procedures • Routine inspections • Engineering design
PR-5	During pneumatic retrieval operations, a vacuum relief valve must be installed on Silo 3, set to −3.0 inches of water, with alarm indication.	Dome Failure, protect Silo Dome TSR	• I-TAB • Routine inspections • Engineering design • Routine calibration and maintenance

10.3 Silos Project Technical Safety Requirement (TSR)

Technical Safety Requirements (TSRs) are the limits, controls, and related requirements necessary for the safe operation of a nuclear facility and, as appropriate for the work and the hazards identified in the documented safety analysis for the facility, includes management controls, use and application provisions, and design features, as well as a basis appendix. TSRs are subject to 10 CFR 830, Subpart B [Ref. 6].

The Silos Project (including Silo 3) has one TSR (see **TABLE 10-2**). There are no additional TSRs specific to the Silo 3 Retrieval and Disposition Project. Planned Silo 3 operations and activities will be conducted within the umbrella of the Silos safety basis (i.e., the Silos TSR). PCN2

When a proposed activity could violate the Silos TSR (or potentially affect some other aspect of the Silos safety basis), the activity will be evaluated using the Safety Analysis Evaluation Process in Addendum 2 of PL-3049, *Implementation Plan for SARs and TSRs at the FEMP* [Ref. 62]. SBR/PR violations that affect the Silos are subject to the Unreviewed Safety Question (USQ) process per NS-0002, *Unreviewed Safety Question (USQ) Determination and Safety Evaluation System* (USQD/SE System) [Ref. 45].

TABLE 10-2: SILOS PROJECT TECHNICAL SAFETY REQUIREMENT (TSR)

TSR	Requirement	Basis/Source	Implementation
TSR-1	ZONE A (within the center 40-ft diameter of the dome): • AREA LIVE LOADS: No loads greater than 1000 pounds, each spread over an area of at least 20 square feet. Loads may be applied simultaneously at not more than two different locations, which are separated by a distance of at least 10 feet within Zone A. • ANNULAR LIVE LOADS: Maximum of 1000 lbs. total, at 30 pounds per square foot, around the openings within Zone A. ZONE B (outside the center 40-ft diameter of the dome): • AREA LIVE LOADS: maximum of 2000 lbs., each spread over an area of at least 20 square feet. Loads may be applied simultaneously at not more than four different locations, which are separated by a distance of at least 20 feet within Zone B. For a dome zone map and further details on limiting conditions on loads and equipment operation, see the OU4 TSR document [Ref. 66].	Worker and co-located worker protection-Technical Safety Requirements Document [Ref. 66]	• Silo Dome Access Permit • Critical Lift Plans • Silos Design Change Notice procedure

10.4 Derivation of Safety Basis Requirements and Process Requirements

Safety Basis Requirements (SBRs) and Process Requirements (PRs) establish a two-tiered system of requirements or controls on the activities at the FCP. The higher-tier requirements are the SBRs, which are derived from specific parameters used for Hazard Categorization or to protect TSRs. The lower tier (PRs) are requirements that either are vital to decrease the likelihood of a potential accident scenario or act as critical accident mitigators to decrease the severity of the consequences of that event. PRs can also act as defense-in-depth for any safety or environmental issue.

The safety requirements derived in this section are applicable to the Silo 3 Facility and result from assessment of the integrated hazard analysis (IHA) discussed in Appendix A. Pre-existing safety basis requirements for the Silo 3 Project were reviewed and then integrated with the IHA, which provided in-depth analysis of the operational tasks identified for the project. This integration of the IHA with previous documentation resulted in a comprehensive list of Evaluation Basis Accidents (EBAs) most likely to be encountered during construction, operation, and maintenance of the Silo 3 project was postulated. These EBAs were then evaluated for consequences, and the results, as well as any associated assumptions were used to identify SBRs and PRs.

Identification of the required SBRs and PRs was completed by a team of Silos personnel representing Operations, Quality Assurance, Engineering, Project Safety, and Nuclear and System Safety. Although none resulted in significant radiological consequences, each of the five EBAs described in Appendix G, as well as Environmental and Operational ALARA details, were considered for potential requirements to protect the Hazard Categorization.

Examination of EBA-1 (hose rupture) did not result in any single component or administrative control that required special protection, as the equipment was of rigorous design and construction, and detection of any spill resulting from hose rupture would be immediate in the occupied facility. Examination of EBA-2 (silo failure due to wall cutting) resulted in SBR-1, to ensure that the work plan for cutting into the Silo 3 wall was documented and implemented with the proper rigor. Examination of EBA-3 (material spill from conveyor) also did not result in any single component or administrative control that required special protection. As was the case for EBA-1, the equipment was of rigorous design and construction, and detection of any spill resulting from conveyor failure would be immediate in the occupied facility.

EBA-4 (package failure during transport to pallet) was examined and two PRs were developed for this scenario. Both PR-2 (gross weight at or below 7000 pounds) and PR-3 (bag meets DOT requirements before transfer to ISA) describe maintaining the bags within the parameters tested for DOT compliance. EBA-5 (filter system failure during retrieval) was examined but did not result in any single component or administrative control that required special protection. This was due to the fact that an abrupt pressure change resulting in filter failure had multiple levels of prevention, and consequences were limited by the immediate loss of ability to pneumatically retrieve.

PRs 1, 4, and 5 were developed to protect parameters outside the EBA scenarios. PR-1 requires capability to measure stack concentration, to meet an environmental release requirement for radon. PR-4 requires a visual inspection of the fabric boot that seals the Silo to the pneumatic retrieval system, because the seal is especially important when pneumatic retrieval is not operating. PR-5

protects the TSR for the Silo dome, as it requires the vacuum relief valve to be set properly to prevent underpressurization of the silo that could cause dome collapse.

11.0 TRAINING REQUIREMENTS

The *Silos Project Training and Qualification Program (TQP) Description*, TQP-067, [Ref. 67] establishes the training and qualification requirements for Silos personnel. The program's objectives are to:

- ensure that workers understand the potential hazards they may encounter.
- ensure that workers possess the knowledge and skills necessary to perform their work with minimal risk to their health and safety.
- ensure that workers are aware of the safety requirements, including the purpose and limitations of safety equipment.
- ensure that workers can safely avoid or escape from emergencies.

The program ensures that workers meet the minimum requirements of 29 CFR 1910.120, DOE Order 5480.20A [Ref. 68] (applicability as described in RM-0043, *FEMP Training Implementation Matrix* [Ref. 69], and other relevant regulations, as applicable.

Health and Safety Training

Workers will receive the appropriate training based on their scope of work. Workers performing activities which fall under 29 CFR 1910.120 [Ref. 70] will receive a required number of hours of initial and annual-refresher health and safety training for hazardous waste site operations. In addition to the initial health and safety training, workers will receive one to three days of directly-supervised field experience.

All personnel performing work under 29 CFR 1910.120 are required to be trained per RM-0055, *FEMP Access* [Ref. 71], in one of the following categories:

- Occasional Site Worker
- General Site Worker

Workers whose work scope does not require hazardous waste site operations training will receive a level of training that is specific to the type of activities to be performed and the hazards to be encountered. Personnel may not participate in field activities until they have been appropriately trained.

Job and Safety Briefings (all hazards)

Before commencement of field activities, all personnel performing fieldwork will participate in a briefing that will specifically address the activities, procedures, monitoring, and equipment used in the work. The briefing will include a description of the work to be accomplished, known hazards

(all types), administrative controls, and PPE requirements. This briefing will also allow field workers to receive clarification of anything they do not understand and to confirm their responsibilities regarding safety and operations for their particular activity.

Project personnel will attend periodic safety briefings/meetings. Briefings will be conducted at the start of the day and at the start of any new task to assist site personnel in safely conducting their work. The briefings will include information on new operations to be conducted, changes in work practices, changes in the project's environmental conditions, and periodic reinforcement of previously-discussed topics. The briefings will also provide a forum to facilitate conformance with safety requirements and to identify safety-related performance deficiencies during daily activities or as a result of safety inspections. The meetings will also be an opportunity for safety personnel to periodically update the crews on monitoring results. Before starting any new activity, an analysis of hazards will be performed and used to inform workers of the potential hazards. There will be an emphasis on particular hazards involved with each job. For example, radiological, chemical, and electrical hazards may be emphasized if pertinent for the operational work that is scheduled to be performed. Written documentation of the briefings and attendance sheets will be maintained as part of the project safety files.

Hazard Communication (chemical hazards)

Hazard communication training will be provided per the OSHA 29 CFR 1910.1200 [Ref. 72] requirements. The training shall provide workers with information on chemicals used on the Silos Project and their potential hazards. The training will be incorporated in formal instruction and/or pre-job briefings. MSDSs, labeling, and other forms of warnings will be used in conjunction with the training to foster worker awareness.

Classes of Silos Personnel and their Training and Qualification Requirements

Management qualifies personnel for a position based on the individual's education, experience, training, and performance. The term "qualification" has a different meaning for each position and may be executed in different ways. There are four primary classes of personnel associated with the Silos Project:

- Fluor Fernald, Inc., Employees: Position descriptions list the applicable selection criteria, including the education and experience requirements, for these Fluor Fernald Employees. TQP-067, *Silos Projects Training and Qualification Program Description* [Ref. 67], identifies training requirements. TQP-067 may identify additional training and requirements, for some personnel, by referring to other Training and Qualification Program Descriptions. The applicable Description will identify the method used to qualify an individual for each position. Methods range from formal qualification to being considered qualified by meeting the hiring criteria.

- Staff Augmentation Personnel: The applicable position requisition and justification documents identify the selection criteria for Staff Augmentation Personnel. TQP-067 identifies training requirements. TQP-067 may identify additional training and requirements, for some personnel, by referring to other Training and Qualification Program Descriptions. The applicable Description will identify the method used to qualify an individual for each position. Methods range from formal qualification to being considered qualified by meeting the hiring criteria.

- Construction/Maintenance Subcontract: Each subcontract identifies the personnel selection criteria (if applicable). The criteria may include education and experience requirements. The subcontract identifies the training requirements for Subcontract Personnel. These requirements are based on the hazards of the work. If qualification is necessary, the subcontract will identify who should be qualified and what qualification method should be used.

- Support Personnel Assigned for Tasks: Support Personnel will support the project periodically for short periods to provide distinct services. Those personnel shall be selected, trained, and qualified per the applicable Training and Qualification Program Description(s) for the services they provide. The supervisor who assigns the individual to work with the Silos Project must ensure that the individual is current in the applicable training requirements identified in RM-0055, *FEMP Access*, [Ref. 71] and all applicable work permits. Personnel will be briefed on the N-HASP and the Construction Safety HASP, if applicable. Personnel shall receive the applicable Pre-Job and RWP briefings, as required. Prior to the start of work, Silos Project Management will ensure that personnel have been trained as specified in the work permits.

Silos Vendors and Visitors

Silos vendors and visitors will not have unescorted access to the Silos Project site. Vendors and visitors will be briefed per this N-HASP commensurate with their planned activities.

12.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

Fluor Fernald provides PPE to the Fluor work force in order to protect them from the various hazards present in the work place. **TABLE 12-1** lists most of the PPE issued to workers at the Silos. Other types of PPE may be required and issued for certain tasks. Levels of protection are subject to change based on air monitoring data, radiological data, and other types of work-area monitoring data. For more information on what PPE to use for a work activity, consult the current RWP, Work Permits, Work Plans, and procedures. RCTs and Fluor Fernald S&H Representatives will provide guidance when needed.

TABLE 12-1: PERSONAL PROTECTIVE EQUIPMENT (PPE)		
Type of Protection	**PPE Name**	**PPE Use**
Respiratory Protection (See Fluor Fernald Respiratory Protection Program [Ref. 73])	Air Purifying Respirator (APR)	For potential airborne contamination, provides a protection factor of 50 (see Note 1)
	Powered Air Purifying Respirator (PAPR) (full-face, tightly-sealed)	For potential airborne contamination, provides a protection factor of 50 for chemical and 1000 for some radionuclides (see Notes 1 and 2)
	Self Contained Breathing Apparatus (SCBA)	For potential airborne contamination, provides a protection factor of 10,000
	Air Line Respirator	For potential airborne contamination, provides a protection factor of 1000
Eye Protection	Safety Glasses with side shields [American national Standards Institute (ANSI) Z-87 approved]	Required for site access and all site activities
	Face shield	Where splash hazard exists
	Cutting goggles (or equivalent cutting shield for use with respiratory protection)	For torch cutting operations.
	Welding Helmet (or equivalent welding shield for use with respiratory protection)	For welding operations

TABLE 12-1: PERSONAL PROTECTIVE EQUIPMENT (PPE)		
Type of Protection	**PPE Name**	**PPE Use**
Hand Protection	Nitrile gloves Leather Palm Gloves Long Leather Gloves (Gauntlets)	Ferrous sulfate Concrete work Sharp edges
Head Protection	Hard Hat (ANSI Z-89 approved)	Required where posted
Foot Protection	Steel-toed boots	Required for all site activities
	Latex overboots	For protection against contamination
	Rubber overshoes	For secure footing in contamination area
	Polyethylene booties	Inner liners. Do not use as outer foot ware.
	Cloth Anti-C Booties	Inner liners. Do not use as outer foot ware.
Skin Contact Protection	Cloth Anti C Coveralls with Hood	For contamination protection
	Tyvek Coveralls with Hood	For contamination protection
	Poly-Coated (Yellow) Tyvek with Hood	For splash protection
	Saranex Coated Tyvek with hood	For heavier splash protection and acid splash
	PVC Coveralls (or overalls with jacket)	For use with acid(s) and caustic solutions
Hearing Protection (See Fluor Fernald Hearing Protection Program [Ref. 74])	Ear Plugs	Use for noises greater that 85 dB (do not exceed rating)
	Ear Muffs (head phones)	For use in conjunction with ear plugs (see Note 3)

TABLE 12-1: PERSONAL PROTECTIVE EQUIPMENT (PPE)		
Type of Protection	**PPE Name**	**PPE Use**
Fall Protection (See Fluor Fernald Fall Protection Program [Ref. 75])	5-point body harness and lanyard	For use where installed fall protection (i.e., railings) is inadequate
	Beam strap	To create a secure tie-off point at a secure location such as a steel beam.

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Note 1: In order to be effective, the cartridge used must be able to filter, absorb, or adsorb the contaminants of concern. Consult RWP, Permits, Plans, MSDS(s), and/or with S&H Representative for more information.

Note 2: PAPRs provide a protection factor of 1000 for some radionuclides (i.e., particulates, which would include thorium-230). Consult the RWP or Radiological Control for more information.

Note 3: Headphones have a lower noise-reduction rating than earplugs, plus wearing hoods and other anti-contamination clothing can further reduce their effective noise rating.

13.0 MEDICAL SURVEILLANCE

Per 29 CFR 1910.120, *Hazardous Waste Operations and Emergency Response*, all personnel assigned to an FCP project and performing actual tasks are required to participate in the Fluor Fernald medical monitoring program.

Medical approval must be received prior to performing work. If an outside medical resource is used to provide any portion of the monitoring program, the individual must receive prior written authorization from Fluor Fernald, which has final approval authority for external medical monitoring programs. Fluor Fernald will provide a list of pre-approved outside medical resources upon request. Fluor Fernald Medical Services will provide minimum requirement protocols for their employees. Medical documentation showing that personnel meet minimum requirements shall be submitted in a sealed envelope marked "SENSITIVE" to the Fluor Fernald Medical Director, Mail Stop 30, with a copy of the transmittal sheet to FCP Document Control.

General Programs

Workers identified as hazardous waste site workers will be required to undergo medical examinations. Supervisors should make employees available for such examinations.

Special medical (health hazard) monitoring requirements as prescribed by 29 CFR 1910, *Occupational Safety and Health Standards*; 29 CFR 1910.120, *Hazardous Waste Operations and Emergency Response*; other federal, state, or local statutes; and specific site HASPs, may be fulfilled by sources outside of Fluor Fernald (e.g., lead and associated tests). Documentation (e.g., copies of medical examinations, laboratory tests, biologic monitoring reports) shall be provided to the Fluor Fernald Medical Director, as specified above. Biological monitoring requirements will be based on the hazardous chemical identified through monitoring.

No food or drink shall be consumed after 11PM prior to scheduled medical pre-assignment monitoring.

Workers shall report any open wounds prior to entry into a Controlled Area. Workers with wounds that cannot be covered are restricted from working in Radiological Areas.

Use of Prescription Medicine

- Non-prescription medicine shall not be taken into Controlled Areas with the single exception of Glucose Tablets which may be taken by diabetics. Employees needing Glucose Tablets shall register with the Fluor Fernald Medical Department.

- Prescription medicine will only be recognized as legitimate for on-site use after the employee to whom the medicine is prescribed registers the medicine with the Fluor Fernald Medical Department.

- In the event of an emergency, an employee may take prescription medicine on the spot, regardless of the area in which he or she is standing. If medicine has been taken under these conditions, the employee should contact Fluor Fernald to determine what action, if any, will be required of the employee in regard to dosimetry.

Employees receiving medical treatment with radio-pharmaceuticals will be restricted from entering Controlled Areas until such time as the radio-pharmaceutical has cleared sufficiently from his/her system so that frisking with a PCM at the control point does not trigger the alarms. Employees receiving such treatment shall report to Fluor Fernald Medical Services beforehand so appropriate precautions can be taken. Employees who have received treatment with radio-pharmaceuticals shall report to Medical immediately upon returning to work.

Pregnant employees should report to Fluor Fernald Medical. The employee will be informed of risks related to her pregnancy as a result of working on the Contract. The employee may "Declare Pregnancy" per 10 CFR 835 [Ref. 53]. If declared, Fluor Fernald will ensure that the employee's TLD is read monthly (as opposed to quarterly). Fluor Fernald's administrative control limit is 50 mrem/month or 400 mrem/gestation period.

Medical Services

The project N-HASP, Work Plans, Work Permits, and RWPs contain information on project-specific hazards to which workers may be exposed.

The Fluor Fernald Medical Department has the following Medical Monitoring Programs in place for workers with potential exposures (including all of the laboratory, x-ray, and other testing ordinarily included in the Biologic Monitoring Program):

- Asbestos Worker
- Hazardous Waste Worker (including radiation)
- Lead Worker (and other heavy metals)
- Hearing Conservation

Some workers are required by regulation to be entered into a long-term Health Surveillance Process Program. Other standards of care/practice in Industrial Hygiene, Occupational Medicine, or Health Physics may also dictate special testing or programs for some workers. Air sampling for various AWR constituents may identify additional medical monitoring if airborne concentrations indicate high airborne levels.

The Fluor Fernald Medical Director will be the final authority to determine the fitness of any worker or his/her suitability to perform work and be exposed to any of the various hazards at the FCP.

14.0 MONITORING

NOTE: This discussion excludes radiological contamination monitoring, which is discussed in Appendix H, *Health Physics Plan*.

A comprehensive air sampling program is essential for evaluating the hazards of work situations with the potential for worker exposure to hazardous substances. In many instances, air sampling data can also provide the basis for development and evaluation of control procedures, and can indicate whether or not operational changes are necessary to provide adequate protection of affected personnel. Air sampling data will be used to define airborne concentrations so that, if necessary, timely additional engineering or administrative controls can be implemented, and to verify that appropriate PPE has been assigned.

Air-contaminant exposures may be created: (1) during the removal of materials from Silo 3; (2) when Silo 3 materials are loaded into containers; (3) when loading containers for transport; and (4) when maintenance activities are performed on Silo 3 equipment. Air-contaminant exposure monitoring will be performed when there is a potential for exposure at or above ½ the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values-Time Weighted Average (TLV-TWA) [Ref. 76] or OSHA Permissible Exposure Level-Time Weighted Average (PEL-TWA) (action level) [Ref. 77], whichever is most restrictive. Personal sampling shall be conducted on the personnel involved in the task with emphasis on those employees with the greatest risk of exposure. Samples will be collected in the workers' breathing zone.

The Silos Project follows established air monitoring requirements as prescribed in the Fluor Fernald site procedures, the National Institute for Occupational Safety and Health (NIOSH) Analytical Methods, and the OSHA and ACGIH Exposure Criteria. Proper implementation of these requirements is necessary to assess the levels of hazardous contaminants in the atmosphere of the working environment.

The approach used is an integrated one that uses real-time air monitoring equipment in conjunction with personal and general area air sampling:

- Real-time Instruments can give immediate data on the levels of contaminants (without specifying which contaminants are being monitored), volatile chemicals, oxygen, and carbon monoxide. Additional qualitative and quantitative information on specific chemicals can be obtained through the use of colormetric (Draeger™) tubes, but they have limited accuracy. However, sulfuric acid Draeger™ tubes may be used since real-time instruments are not available for this contaminant.

- Personal and General Area air sampling can give more specific and accurate data on the levels of individual components of the atmosphere. However, the samples must be sent to a lab for analysis and the results are not immediately known. See Section 8.19 for further discussion of personal air sampling and the chemicals of concern.

TABLE 14-1 lists the various types of real-time air monitoring equipment used at the Silos, the associated action levels along with the response action(s), the various PELs and TLVs and the response actions if the PELs or TLVs are exceeded. The response to a detection by a colormetric (Draeger) tube will vary based on the chemical. Ordinarily, the use of a colormetric tube will be integrated with another real-time method such as a Photo Ionization Detector (PID).

TABLE 14-1: REAL-TIME IH AIR MONITORING EQUIPMENT, ACTION LEVELS, AND RESPONSES

Monitor	Action Level	Action to be taken	PEL or TLV	Response
Oxygen	Greater than 23.5% or less than 19.5%	• Evacuate area • Investigate • Upgrade to SCBA or supplied air protection respirator for re-entry	NA	NA
Combustible Gas Indicator (CGI)	$\geq$ 10 % LEL	• Immediately stop all hot work activity • Evacuate area • Investigate	NA	NA
Carbon Monoxide	$\geq$ 12.5 PPM	• Investigate source and mitigate • Ventilate area	25 PPM	• Evacuate area • Ventilate area

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TABLE 14-1: REAL-TIME IH AIR MONITORING EQUIPMENT, ACTION LEVELS, AND RESPONSES				
Monitor	**Action Level**	**Action to be taken**	**PEL or TLV**	**Response**
Photo Ionization Detector (PID)	≥ 10 PPM	• Investigate source and mitigate	PEL or TLV	At a minimum, wear chemical cartridge respirator
Colormetric (Draeger) tubes	≥ ½ PEL	Various. Typically: • Investigate source and mitigate	PEL	Various. Typically: • Evacuate area • Upgrade level of protection, as appropriate

Noise monitoring and illumination-level surveys may also be performed during Silo 3 maintenance and operations activities. Noise monitoring will be conducted per OSHA 29 CFR 1910 [Ref. 77]. Workers utilizing equipment capable of generating hazardous noise levels and/or working in areas with potential hazardous noise levels will be evaluated to determine exposure levels and the necessary controls. Also, areas with suspected high noise levels shall be evaluated to identify high noise sources and to aid in determining engineering and administrative controls.

Illumination surveys will be performed and illumination levels will be maintained per 29 CFR 1910 [Ref. 77] and Illuminating Engineering Society of North America (IES) guidelines [Ref. 78]. Supplemental lighting sufficient to meet the regulatory guidelines shall be provided, as necessary.

Data Quality Assurance

All instruments (air, noise, heat/cold, and illumination) shall be calibrated as specified by the manufacturer. Duplicate readings may be taken to confirm individual instrument response. Also, all instruments will be maintained in good working order as specified by the manufacturer. Air-sampling pumps used to collect worker-exposure samples shall be calibrated before and after sample collection. Calibrations shall be accomplished using a primary standard calibration system. Results of the calibrations shall be included on air-sampling data sheets. Calibration of noise-monitoring equipment will be performed per manufacturers' guidelines. Results of the calibrations shall be included on noise-survey data sheets.

Data Review

S&H personnel shall review the analytical results to evaluate the potential for worker exposure, upgrade/downgrade of protection limits, and changes in sampling/monitoring strategy. Reports and correspondence will be generated per procedure 602-5024, *Industrial Hygiene Air Sampling Program* [Ref. 79].

Laboratory Analysis

Chemical analysis of samples collected for assessment of employee exposures shall be performed only by analytical laboratories accredited by the American Industrial Hygiene Association. The laboratory analysis will include field blanks, as required by the individual method or laboratory. Duplicate samples or splits with other laboratories may be used during the project. The laboratory shall also be a successful participant in the Proficiency Analytical Test (PAT) program for the category of material they are analyzing.

15.0 DECONTAMINATION PLAN

The Silos Project is a hazardous waste remediation project. Any person working in an area where the potential for exposure to project contaminants exists will only be allowed access after providing evidence of proper training and proper medical documentation.

During the conduct of Silo 3 activities, various work areas will be established. Entrances to, and perimeters of, Radiological Areas will be defined by yellow snow fencing and/or yellow-and-magenta rope. All radiological areas will be identified by signs having the standard radiation symbol (the tri-foil) on a yellow background and inserts describing the reason for the boundary and the controls necessary for entry.

Personnel Decontamination

Any circumstance that could have resulted in an intake of radioactive materials by inhalation, ingestion, absorption, or injection shall be immediately reported to a supervisor. The supervisor shall immediately report the circumstance of possible radioactive materials intake to an RCT for evaluation. Radiological Control/Medical will determine further actions.

If radioactive contamination is detected on the skin or clothing, contact an RCT immediately. When performing personnel contamination monitoring with automated instrumentation such as a PCM or a Hand and Foot Monitor (HFM), all alarms must be reported to an RCT for an evaluation before proceeding from the area. When performing manual personnel surveys with portable instruments (friskers), detection of a net count rate exceeding Fluor Fernald limits specified in the RWP should alert personnel of possible contamination.

Depending on the nature, location, and extent of the personnel contamination, Radiological Control may direct the contaminated personnel to initiate a bioassay analysis to assess a potential internal radiation dose from possible inhalation, ingestion, absorption, or injection of radioactive materials.

Decontamination of radiological and some chemical contaminants may be required during the conduct of Silo 3 operations. This will be accomplished by the use of or a combination of HEPA-filtered vacuum units, wet-wiping techniques, approved detergents or soaps, or the use of sealants or fixatives when immediate decontamination is not feasible or practical. Decontamination areas will be established for personnel decontamination and equipment decontamination.

Any circumstance that could have resulted in an intake of radioactive materials by inhalation, ingestion, absorption, or injection shall be immediately reported to a supervisor. The supervisor shall immediately report the circumstance of possible radioactive materials intake to an RCT for evaluation. Radiological Control/Medical will determine further actions.

In the unlikely case of body contact with an acid or caustic agent, non-permeable PPE should be doffed with extreme caution to prevent contact with the skin. Contaminated inner clothing shall be removed. The affected body area shall be washed thoroughly (15 minutes minimum) in a safety shower or eye bubbler in the case of a splash into the eye(s). Involved personnel shall report immediately to their supervisor and Medical.

In many cases, chemical contamination can be removed by physical means involving rinsing, wiping off, or vacuuming. Additional efforts to decontaminate may include the use of mild soap and/or soft-bristle brushes. Efforts shall be made to prevent loose chemical contamination from entering body openings and to prevent breaking the skin barrier. If the skin barrier is removed or breached during decontamination, medical assistance will be sought. Sensitive areas such as eyes, body cavities, or wounds are more difficult to decontaminate and will be dealt with by Medical.

If immediate medical treatment is required to save a life, decontamination will be delayed until the victim is stabilized.

Equipment Decontamination

If equipment becomes contaminated during a Silo 3 operation or maintenance activity, Radiological Control personnel will establish an area to perform the necessary decontamination. The area configuration will be based on the actual size of the equipment, levels of contamination, dispersability of the contamination, and the methods for performing the decontamination.

For chemical decontamination, efforts will be made to avoid coming into contact with the contaminated equipment. Standing or walking through pools of liquid will be discouraged. Objects may be encapsulated with plastic sheeting or other material to prevent contact with contaminated items. Physical removal methods for chemical contamination may include using water with a mild soap, vacuuming, scraping, brushing, and wiping. Surfactants, such as detergents, may be used to augment physical cleaning methods by reducing adhesion forces between chemical contaminants and the surface being cleaned, and by preventing redeposit of the contaminants.

16.0 EMERGENCY RESPONSE PLAN

The Silos Emergency Plan has been developed to cover extraordinary conditions that might occur at the Silos and is to be used in conjunction with Fluor Fernald Site Emergency Action Plan.

Silos project personnel have the responsibility to be aware of the actions required of them under all site emergency procedures. However, there are two emergency procedures that require particular emphasis:

- EM-0020, *Building Emergency Procedure* [Ref. 80]
- EM-0030, *Silos Area Emergency Procedure* [Ref. 81]

EM-0020 provides details for standard emergencies (e.g., Fire, Severe Weather, Bomb Threat). EM-0030 provides detail for actions to be taken in the event of a potential significant release of radon from Silos 1 or 2.

Reporting

TABLE 16-1 lists the emergency numbers that shall be used to report emergencies at the Silos:

TABLE 16-1: FCP EMERGENCY NUMBERS

EMERGENCY RESOURCE	FCP PHONE EXT.	NON-FCP PHONE/CELL	RADIO
Ambulance	911	513-648-6511	Control
Hospital	911	513-648-6511	Control
Fire	911	513-648-6511	Control
Security	911	513-648-6511	Control
Emergency Response	911	513-648-6511	Control
Assistant Emergency Duty Officer (AEDO)	4749 4444	513-648-4749 513-648-4444	202/Control

Site Notification Procedures

All emergencies shall be reported to the Fluor Fernald Communication Center to ensure rapid response. Whenever personnel are working, a means to report emergencies shall be available at all work locations. This may be accomplished by one or more of the following methods:

- Dial 911 on any site phone
- Dial 513-648-6511 on cell phones or any non-FCP phone
- Activate any fire alarm station
- Radio to Control

Any injury, no matter how minor, shall be reported to FCP Medical Department for evaluation or treatment. The injured party shall be accompanied by the supervisor in charge or his designee. The Silos S&H Representative shall be notified as soon as possible after the injury/accident has occurred.

Personnel will be notified of emergency or abnormal conditions by the plant-wide alarm system and radio announcements. Announcements follow the sounding of the site alarm horn signal. Emergencies may also be announced by fire-alarm pull stations, which are programmed to alarm locally and at the Emergency Operations Center.

What to Report

The following are examples of emergencies that justify calling and reporting:

- Serious Injury
- Injury Complicated by Contamination
- Hazardous Waste or Hazardous Substance Emergency
- Radiation/Contamination Release
- Chemical Splash (Eye and Skin)
- Chemical Spill
- Any Fire
- Property Damage
- Adverse Weather Conditions
- Atypical Events
- Loss of Containment
- Loss of Utilities

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When an emergency or abnormal condition is observed, personnel shall contact the Communications Center at extension 911 or via radio (Control). Stay on the phone line until the dispatcher hangs up. The following information must be given to the Communications Center Operator:

- Name
- Badge Number
- Location of emergency
- Nature of emergency

- Number of personnel with injuries
- Unusual conditions (odors, symptoms, vapors, smoke)
- Current status of the emergency

Evacuation Routes

Should a situation require an emergency evacuation of the work areas, all equipment should be shut off (if possible) and left in place. Personnel should immediately proceed to primary Rally Point 4 (on the west side of the 30/45 parking lot). The back-up assembly area is located at the WPRAP parking lot. PCN2

Emergency Response

FCP Emergency Services will handle all emergencies. Any request for emergency help should be requested by telephone (911) or on any FCP radio frequency by calling Control.

Medical Emergencies

For a medical emergency at the FCP, call 911 (by site phone) or 513-648-6511 (by cell or non-site phone) or on any FCP radio frequency by calling Control Channel 2. The FCP Communications Center will contact the off-site Subcontracted Response Team regarding the emergency. The Subcontracted Response Team will initially treat the individual at the scene and then transport him/her to a local hospital emergency room. PCN2

Fire Emergencies

All work sites shall maintain effective communication to summon fire-fighting assistance. Access to work areas shall be maintained at all times to permit fire trucks and fire-fighting crews to safely approach the fire emergency.

Only trained personnel shall attempt to operate any fire-fighting equipment and only when the fire is clearly within the capability of the fire-fighting equipment.

The Subcontracted Response Forces will respond to all on-site fire emergencies. For any fire at the FCP, call 911 (by site phone) or 513-648-6511 (by cell or non-site phone) or on any FCP radio frequency by calling Control Channel 2. PCN2

Explosion Emergencies

When an explosion has occurred, the following actions are to be taken:

1. Activate the closest fire alarm, if possible. If a fire alarm is not available, notify other employees by an alternate method (radio Supervisor or Control). PCN2

2. Evacuate the work area.

3. Proceed to the appointed rally point.

   NOTE: The primary rally point is Rally Point 4 (on the west side of the 30/45 parking lot). The back-up assembly area is located at the WPRAP parking lot.

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4. If qualified, render first-aid to any injured personnel.

5. Instruct all persons in transit to avoid the work area and surrounding area.

6. Contact Control by radio or by phone (911).

7. Call for medical assistance, if necessary.

8. Report to your supervisor for accountability.

Chemical Emergencies

Splashes

Flush the affected area for 15 minutes and report to Medical Services. Remember to always follow the MSDS guideline.

Personal Contamination (Chemical)

When contaminated with a corrosive or caustic material, flush the affected area with clean water for 15 minutes. Report to Medical Services. The injured party shall be accompanied by the supervisor in charge or his designee. The Silos S&H Representative shall be notified as soon as possible after the injury/accident has occurred.

All instances of personal chemical contamination shall be reported to Silos S&H Representative, the AEDO, Silos Project management, and the RCS Control Room.

Any situation which could have resulted in the inhalation, ingestion, or absorption of a hazardous material shall immediately be reported to supervision and the Silos S&H Representative and the AEDO, who will report the circumstances to Medical Services. The involved personnel shall be directed by the AEDO or Supervision as to when and where to report for medical evaluation, completion of an Incident Investigation Report, and submission of bioassay samples (e.g., blood, urine).

Radiological Emergencies

Radiological Releases

For all radiological releases, the release area shall be evacuated. The Supervisor in charge, AEDO, RCTs, Silos Project management, a Silos S&H Representative, and the RCS Control Room shall be notified of the release.

If a silo dome failure occurs on one of the domes, all work shall be stopped in the Silos area, and the actions of EM-0030, *Silos Area Emergency Procedure* [Ref. 81], shall be followed.

Hazardous Waste/Substance Emergencies

Uncontrolled Hazardous Waste or Hazardous Substance Release

Under 29 CFR 1910.120, *Hazardous Waste Operations and Emergency Response,* an emergency exists when a site experiences an occurrence that results in, or is likely to result in, an uncontrolled hazardous waste or hazardous substance release, causing a potential health or safety hazard that cannot be mitigated by personnel in the immediate work area where the release occurs. In the case of an emergency, trained responders from the Fluor Fernald Emergency Response Organization will be relied upon for response.

Silos Project personnel will assist Fluor Fernald Emergency Response by providing detailed information regarding the emergency and any technical input needed to ensure the safety of the responders, the public, and the environment.

Incidental Release of Hazardous Substances

Under 29 CFR 1910.120 (a) (3), responses to incidental releases of hazardous substances where the substance can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel, are not considered to be emergency responses within the scope of HAZWOPER. Responses to releases of hazardous substances where a potential health or safety hazard (i.e., fire, explosion, or chemical exposure) does not exist are considered to be non-emergency responses.

Management will ensure that only qualified personnel, trained in incidental release clean-up under the Hazard Communication Standard, will respond to incidental releases. These personnel are not considered emergency responders.

Spill Response

In order to prevent the spread of contamination from spills of hazardous chemicals, Fluor Fernald has provided the following controls for the Silos. In most instances, spills should be cleaned up quickly before they become larger or contaminate larger areas. Large spills should only be handled with the assistance of Subcontracted Emergency Response Services. PCN2

- Engineering Spill Controls: Secondary containment will be provided for any acid and caustic storage tanks determined to be necessary. Fuel cells are double-walled for containment of leaks. Floor areas are sloped to allow spilled materials to be collected in containment sumps.

- Administrative Spill Controls: Spill control kits will be placed in strategic areas. Specific spill-response steps are provided in the appropriate Fluor Fernald procedures. Only personnel trained in performing spill response should attempt to implement these procedures.

General Spill Guidelines

The following guidelines are provided as basic information on spill response. These guidelines would apply to any spill potentials envisioned for the Silo 3 Project. Consult the applicable procedure, MSDS, or Work Plan for detailed spill response guidelines:

1. Before the task begins, review and be familiar with the MSDS or appropriate document for the chemical to be used.

2. Before the task begins, note the location(s) of the nearest spill kit(s) and ensure they are adequately stocked.

3. In the event of a spill, remove personnel from the area, as appropriate.

4. Contact your supervisor.

5. If the spill is large enough, it may require the assistance of the FCP Emergency Response Team. The supervisor shall contact them.

6. Barricade the spill area by the use of caution tape or another appropriate method.

7. Before entering the spill area, assure that the appropriate air monitoring has been performed.

8. Before entering the spill area, upgrade the level of protection, as necessary.

9. Prevent the spill from spreading any further by containing it with absorbent "socks," pads, or any compatible material.

10. Clean the spill by moving from the less-contaminated areas to the more-contaminated areas.

11. After cleaning the area, ensure that the area is safe for entry by use of air monitoring or other appropriate method before removing the barricade.

12. After cleaning the area, contain and dispose of the spilled material and PPE appropriately.

Post-Emergency Response

Post-emergency response is defined under HAZWOPER as that portion of an emergency response performed after the immediate threat of a release has been stabilized or eliminated and cleanup of the site has begun. Making this distinction is critical because, among other things, different training requirements and different exposure levels may apply depending on the phase of response. If post-emergency response is performed by personnel who were part of initial emergency response, it is considered to be part of the initial response and not post-emergency response.

Weather Limitations/Adverse Conditions

Any outside work will be suspended if warnings for high winds, lightning, or tornadoes are sounded. Any operations utilizing cranes or personnel working on elevated steel will be suspended if wind velocity reaches 25 mph.

Personnel will assemble in the Excavator Room when severe weather approaches and/or signaled to do so via the Emergency Message System. PCN2

17.0 OCCURRENCE REPORTING

DOE's Occurrence Reporting Program provides timely notification to the DOE Complex of events that could adversely affect: public or DOE worker health and safety, the environment, national security, DOE's safeguards and security interests, functioning of DOE facilities, or the Department's reputation. DOE analyzes aggregate occurrence information for generic implications and operational improvements. The Program and its data system, the ORPS, are described in DOE Order 231.1A [Ref. 82] and its associated manual, DOE Manual 231.1-2 [Ref. 83]. PCN2

DOE Order 231.1A arranges occurrences into ten groups that relate to DOE operations. These ten groupings are used solely for ease of reference and do not represent program requirements. The categories of occurrences are designed to be generic. The ten groups of categorized occurrences are:

1. Facility Condition
2. Environmental
3. Personnel Safety
4. Personnel Radiation Protection
5. Safeguards and Security
6. Transportation
7. Value Basis Reporting
8. Facility Status
9. Nuclear Explosive Safety (not applicable at the FCP)
10. Cross-Category Items

Implementation of ORPS at the FCP is performed by the Occurrence Reporting Team (ORT) of the Safety & Health Department, SH&Q Division, per SH-0028, *Occurrence Reporting* [Ref. 43] and SH-1006, *Event Investigation and Reporting* [Ref. 61].

Price-Anderson Amendments Act (PAAA) Background and Implementation

The Price-Anderson Amendments Act (PAAA) of 1988 provides indemnification (i.e., "nuclear insurance") to DOE contractors who manage and operate nuclear facilities in the DOE complex. Under this act, DOE contractors, subcontractors, and suppliers are subject to criminal and civil penalties for violations of nuclear safety requirements. Civil penalties (fines) are assessed against companies (not individuals). Criminal penalties include incarceration for individuals at all levels where egregious violations are committed. PCN2

DOE's complex-wide Noncompliance Tracking System (NTS) database is provided for contractors to report PAAA NTS reportable noncompliances. When PAAA noncompliances are identified as NTS reportable, the contractor must post the initial report on NTS within 20 calendar days of the event discovery. The established system is used to identify, report, track, trend, and develop corrective actions for noncompliance issues covered by PAAA and its implementing regulations ("nuclear safety requirements"). Current DOE nuclear safety requirements include the following rules, or sections thereof:

- 10 CFR 707, *Workplace Substance Abuse Programs at DOE Sites* [Ref. 84]
- 10 CFR 708, *DOE Contractor Employee Protection Program* [Ref. 85]
- 10 CFR 820.11, *Information Requirements* [Ref. 86]
- 10 CFR 830, *Nuclear Safety Requirements* [Ref. 6]
  - Subpart A: *Quality Assurance Requirements*
  - Subpart B: *Safety Basis Requirements*
- 10 CFR 835, *Occupational Radiation Protection* [Ref. 53]
- 15 CFR 280, *Fastener Quality Act* [Ref. 87]

In 1993, 10 CFR 820, *Procedural Rules for DOE Nuclear Activities* [Ref. 88], and 10 CFR 820 Appendix A, *General Statement of DOE Enforcement Policy*, were promulgated to promote and protect the radiological health and safety of the public and workers at DOE facilities by ensuring compliance with nuclear safety requirements, providing positive incentives for specific actions, deterring future violations, and encouraging continuous overall improvement of operations. The enforcement policy applies to all indemnified DOE contractors, subcontractors, and other suppliers who are responsible for performing activities or supplying services or products subject to DOE nuclear safety requirements.

FCP implementation of PAAA is performed by assigned individuals within the SH&Q Division and involves process owners in any organization. MS-1008, *Identifying, Reporting, and Tracking Price-Anderson Amendments Act Noncompliances* [Ref. 89] is Fluor Fernald's site-level procedure on noncompliance screening and reporting classification. MS-1008 provides direction, guidance information, definitions, clarifications, and/or interpretations of specific terms and requirements contained in applicable documents. Fluor Fernald has also implemented a program for reporting noncompliances with PAAA rules. Per DOE guidance, Fluor Fernald uses DOE's complex-wide NTS for "NTS reportable" noncompliances and also maintains an internal system (PAAA Database) for reporting and tracking "non-NTS reportable" noncompliances.

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18.0 MAINTENANCE MANAGEMENT

The Fluor Fernald *Maintenance Implementation Plan (MIP)*, PL-3080, constitutes an agreement among the DOE Ohio Field Office, DOE-FCP, FCP (formerly the FEMP), and Fluor Fernald, Inc., on the implementation of the requirements of DOE Order 4330.4B, *Maintenance Management Program* [Ref. 90]. The MIP defines the programs and procedures in place to address the elements of the order at the FCP. The seven guiding principles and five core functions of Integrated Safety Management are incorporated in maintenance planning and execution.

The MIP addresses implementation of programmatic requirements and provides a listing of implementing documents and procedures. A graded approach, consistent with DOE Order 4330.4B guidance for nonreactor nuclear facilities, is used to define the depth of detail required, and magnitude of resources expended for, Fluor Fernald maintenance management elements commensurate with each element's relative importance to safety, environmental protection and compliance, safeguards and security, property preservation, fulfillment of the programmatic mission, and/or other facility-specific requirements. The Fluor Fernald maintenance management program policy states that all DOE property must be maintained in a manner which promotes operational safety, worker health, environmental protection and compliance, property preservation, and cost-effectiveness while meeting the programmatic mission. Structures, systems, and components that are important to safe operation will be subject to a maintenance program in order to meet or exceed their design requirements throughout their life.

A master equipment list of structures, systems, and components identified for tracking at the FCP is maintained in a computerized maintenance management database called the TabWare System. This listing has been graded in accordance with site engineering procedure ED-12-4015, *Performance Grading* [Ref. 91], which provides guidance for applying a performance grade to all components on the equipment list. The performance grade then establishes the basis for applying a graded approach to the level of review and documentation necessary for implementing maintenance and safety requirements. The TabWare System is the management system used to plan, schedule, track, store, review, and analyze data for work requests/orders.

The Silos Project will follow the MIP and MT-0003, *FEMP Work Request/Order Procedure* [Ref. 92], for the conduct of maintenance. The Silos Operations and Maintenance Group will provide oversight, first-line supervision, and utilize FAT&LC personnel to perform maintenance activities. The maintenance organization will use maintenance reference guides to provide a systematic approach in analyzing maintenance requirements for planning, scheduling, coordination, and overseeing the completion of maintenance activities for the project. The Silos Project will develop preventive maintenance and standard repair maintenance procedures that will be incorporated in the TabWare System. In addition, the project will establish a spare parts list and inventory and will be responsible for the performance of required calibrations.

19.0 QUALITY ASSURANCE PROGRAM

Fluor Fernald's *Quality Assurance Program (QAP),* RM-0012 [Ref. 93], is based on the appropriate criteria and requirements specified in 10 CFR Part 830 Subpart A, *Quality Assurance Requirements* [Ref. 94]. This QAP, approved by DOE Letter DOE-0359-03 [Ref. 95] dated May 5, 2003, establishes quality assurance requirements for the conduct of activities, including items or services, that affect or may affect nuclear safety of DOE nuclear facilities. The QAP establishes the QA requirements for Fluor Fernald and all other contractor and subcontractor organizations performing work at the FCP. The QAP identifies and describes the integral elements of the QA activities that apply to the broad spectrum of work performed at the FCP.

The QAP, along with its associated policies and procedures, establishes a system for achieving or exceeding the required quality levels for FCP activities. Where, and to the extent that, activities must be controlled and performed in specific manners or steps, procedures and work instructions will be used with a level of specificity appropriate to the importance or hazard of the activity. Personnel will be trained to these procedures and instructions and will be expected to follow them exactly. In the event that personnel believe that procedural compliance is unwise or unsafe, they will stop work at a position of process safety and stability and resolve the concerns with appropriate supervision. Procedural changes will then be made, as appropriate, to continue work.

Major Silos work activities include remedial actions, construction, decontamination and decommissioning, program management, and support activities. Project planning, design, and execution are performed in compliance with applicable QA and safety and health regulations, and Fluor Fernald, Inc. policies and procedures using a balanced approach. Silos Quality Assurance management coordinates independent QA assessments and QC inspections and surveillances including review and approval of document submittals and Title III inspection of construction activities. QA personnel are certified/qualified/trained to perform assigned activities, as required.

A special QA program plan has been developed for the Silos Project. The *Quality Assurance Job Specific Plan for the Silos Project*, 40000-QA-0001 [Ref. 96], describes the programs and procedures needed to achieve and verify quality for the Silos Project. These programs and procedures implement the applicable broad requirements of the QAP and define specific implementation strategy, tailored to achieve and verify quality in design, construction, closure, monitoring, and documentation.

For record purposes, the basic requirements of DOE Order 414.1A, *Quality Assurance* [Ref. 97], and 10 CFR Part 830 Subpart A are identical. 10 CFR Part 830 Subpart A is intended to supersede the existing requirements in DOE Order 414.1A. Approved management programs based on DOE Order 414.1A will meet the requirements of 10 CFR Part 830 Subpart A.

20.0 REFERENCES

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2. 10 CFR 830.204, *Documented Safety Analysis,* Title 10 Code of Federal Regulations, Part 830, Subpart 204, DOE; January 10, 2001

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Silo 3 BDD

Appendix A

APPENDIX A
INTEGRATED HAZARD ANALYSIS

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ACRONYMS

CFR = Code of Federal Regulations
DOE = U.S. Department of Energy
FAT&LC = Fernald Atomic Workers and Labor Council
FCP = Fernald Closure Project
FMPC = Feed Materials Production Center
IHA = Integrated Hazard Analysis
MRS = Mechanical Retrieval System
NHASP = Nuclear Health and Safety Plan
OS&H = Occupational Safety and Health
OU = Operable unit
PHAR = Preliminary Hazard Analysis Report
PRS = Pneumatic Retrieval System
RMRS = Rocky Mountain Remediation Services
S&M = Surveillance and Maintenance
SSC = Structures, systems, and components
WSA = Waste Storage Area

EXECUTIVE SUMMARY

This Integrated Hazard Analysis (IHA) report forms the basis for the development of the HASP, which contains hazard analyses and facility hazard categorization in accordance with DOE-STD-3009-94. The IHA is a qualitative analytical tool usually performed early in the life of a project to systematically identify, collect, and integrate information on health and safety issues concerning:

- identification of hazards (materials in quantity, form, and location)
- energy sources, potential initiating events, causes of hazardous conditions
- consequences of hazardous events without preventive/mitigative measures
- preventive/mitigative measures
- frequency of occurrence of events (credibility of consequences)
- severity of consequences of events
- significance of hazards (risk, real and perceived)

This IHA contains tables that summarize the hazards of various tasks and subtasks within the Silo 3 Retrieval and Disposition Project. To ensure that the hazards considered are all inclusive, an IHA workshop was held in June 2001 with staff from Fluor Fernald, Inc., and Jacobs Engineering Group – representing engineering, project management, and all health and safety disciplines, as well as union technicians. The health and safety hazards were reevaluated at this workshop to identify all possible hazards that may be encountered within the Silo 3 Project. Updates have been incorporated to reflect changes to design and scope that have occurred since the workshop.

All types of hazards were considered and documented, including standard industrial hazards, human capability limitations, health hazards, electrical hazards, energy-release hazards, radiological hazards, biological hazards, toxic and hazardous materials, and natural phenomena. The results of the analysis are presented in the tables in this IHA. All of the activities were analyzed against a master list of hazards to decide which were potentially applicable.

The identified hazards were entered into the Final Hazard Assessment Table along with possible causes, potential consequences, and estimated frequency and severity on the basis of experience and judgment. Controls and mitigators for all hazards were identified. This information was then used to identify safety hazards that require special attention and/or additional analysis.

The methodology described in SECTION A-3.0 was used to assess the project hazards. All the potential hazards were anticipated or unlikely accidents with very low consequences. The following exceptions are significant hazards that require further analysis:

- Structural failure of silo due to a dropped load, excessive load, or earthquake
- Hose rupture during pneumatic retrieval
- Silo wall failure due to wall cutting operations
- Spill material due to a conveyor failure

- Breach of a material storage bag
- Dust collector failure
- Silo depressurization and collapse
- Spill of ferrous sulfate
- Breach of DOT package in ISA

PCN2

The frequency and severity of the standard industrial hazards are not specified in the Final Hazard Assessment Table, which is consistent with the *Hazard Analysis Report for Operable Unit 4 (OU4)*, Appendix B. However, some standard industrial hazards with unlikely frequency may have significant consequences and these hazards warrant some additional consideration. Electrical energy, confined space, and potential energy or elevation hazards have an unlikely frequency and moderately severe consequences, including the possibility of death. The consequence of contact with electrical sources may be a fatal electrocution. The consequence of working in a confined space may be a fatal asphyxiation. The consequence of working at elevated heights may be a fatal fall.

Minor accidents may be expected to occur during the life of the Silo 3 Project. A strong, comprehensive health and safety program has been established to minimize the actual frequency of such accidents.

A-1.0 INTRODUCTION

The purpose of this Integrated Hazard Analysis (IHA) is to provide an integrated identification and qualitative analysis of the hazards associated with the Silo 3 Retrieval and Disposition Project. This IHA forms the basis for the development of the Nuclear Health and Safety Plan (NHASP), which contains hazard analyses and facility hazard categorization in accordance with DOE-STD-3009-94 [Ref. 1].

The IHA is a qualitative analytical tool usually performed early in the life of a project to systematically identify, collect, and integrate information on health and safety issues concerning:

- identification of hazards (materials in quantity, form, and location)
- energy sources, potential initiating events, causes of hazardous conditions
- consequences of hazardous events without preventive/mitigative measures
- preventive/mitigative measures
- frequency of occurrence of events (credibility of consequences)
- severity of consequences of events
- significance of hazards (risk, real and perceived)

The initial activity required by NS-0005, *Initiating, Reviewing, and Approving DOE-Approved SBDs* [Ref. 2], is an IHA workshop, which was conducted June 26, 2001. The results of the IHA workshop are incorporated into this IHA, as are updates that incorporate changes to design and scope that have occurred since the workshop.

The IHA workshop involved a multidisciplinary team that consisted of approximately 25 individuals from Jacobs and Fluor Fernald, Inc. The disciplines represented were engineering, occupational safety and health (OS&H), radiological control, industrial hygiene, operations, construction, and waste management. In addition, the Fernald Atomic Workers and Labor Council (FAT&LC) was represented.

A-1.1 Scope

The scope of activities included within this IHA includes the continued storage, surveillance and maintenance (S&M), construction, operation, maintenance, and demobilization of the Silo 3 Project. However, the scope of this N-HASP is limited to operation and maintenance of the retrieval and disposition activities. Approximately 5,088 yd^3 of byproduct metal oxide material stored in Silo 3 will be removed, treated, packaged, and transported to an off-site facility for treatment and/or disposal. Access and retrieval will be accomplished by both pneumatic and mechanical systems. The material will be transferred to a Process Building where the material will be fed into storage bags. Hazards associated with all activities in the Silo 3 Facility are addressed and analyzed in this IHA.

A-1.2 Description Of Documentation

This IHA is organized into 6 major sections. This introduction is followed by SECTION A-2.0, which provides background information on the Fernald silos and a description of the Silo 3 Project. The description incorporates by reference the system design descriptions detailed in the *Process Description for the Silo 3 Project* [Ref. 3]. These detailed descriptions provide the basis for identifying hazards that can occur at any step of the storage, S&M, construction, operation, maintenance, or demobilization of the Silo 3 Project. SECTION A-3.0 provides the methods used in performing the final integrated hazard analysis, and SECTION A-3.1 delineates the tasks and subtasks of the Silo 3 and presents the final integrated hazard analysis table. SECTION A-5.0 includes the conclusions of the final integrated hazard analysis, the hazards of concern, and the resolutions of these concerns. SECTION A-6.0 contains the references.

A-2.0 PROJECT DESCRIPTION

From 1952 until 1989, the Fernald site provided high-purity uranium metal products to support U.S. defense programs. Uranium production halted in 1989 because of declining demand and a recognized need to commit available resources to environmental remediation. Former uranium operations at the site were limited to a fenced 136-acre tract of land known as the Production Area located near the center of the site. Large quantities of liquid and solid wastes were generated by the various production operations at the site. Before 1984, solid and slurried wastes from processes were stored or disposed of in the Waste Storage Area (WSA). This area, located west of the production facilities, includes six low-level radioactive waste storage pits, two concrete silos with earthen berms containing K-65 residues, one concrete silo containing metal oxides, one unused concrete silo, two lime sludge ponds, a burn pit, a clearwell, and a solid waste

landfill. The WSA is addressed under OUs 1, 2, and 4. The former Production Area and WSA are fenced and closed to the general public. The remaining areas consist of forest and pasture lands [Ref. 4].

Silo 3 was constructed for the transfer and storage of "cold" 11(e) 2 uranium processing byproduct material (as designated by the Atomic Energy Act) generated through refinery operations at the Feed Materials Production Center (FMPC), now known as the Fernald Closure Project (FCP). The Silo 3 material is a byproduct of uranium ore concentrate processing. The ore concentrates had been preprocessed through a uranium mill where a significant portion of the ^{226}Ra and the gamma-emitting progeny were removed, and thus they were termed "cold" feed material. Silo 3 received metal oxide raffinates generated by all FMPC refinery operations from May 1954 until late 1957.

A-2.1 Silo 3 Facility

Silo 3 was constructed in 1952 and is located south of the Waste Pit Area of the FCP property. Silo 3 is a freestanding, pre-stressed concrete, domed silo approximately 80 feet in diameter and approximately 25 feet above ground level (vertical wall). The floor system is constructed of approximately 17 inches of compacted clay, a 2-inch-thick layer of asphaltic concrete, and an 8-inch layer of gravel topped by 4 inches of concrete. Silo 3 has no under drain system. The domed roof tapers from 8 inches thick at the silo walls to 4 inches thick at the apex. The apex is 36 feet high. Increased reinforcing around the dome periphery (ring beam) is provided to support the additional loading from the pneumatic transfer system that has since been removed.

The Remedial Investigation conducted for Silo 3 [Ref. 4] reveals that the silo contains approximately 5,088 yd^3 of residue. Based on an estimated in situ material density ranging from 29 to 58 pounds per cubic foot (lb/ft^3), the available silo material weighs approximately 3,925 tons.

The physical composition of the Silo 3 waste, based on process knowledge and visual observations, is:

- potentially dry, loose, or fine powder at the top
- compacted powder towards the central and lower portions
- potentially water-saturated powder at bottom (approximately 1 ft)

On December 20, 1991, a project was initiated to ensure that all penetrations through the Silo 3 dome were covered and sealed. Removal of the dust collector and permanent sealing of all obvious open pathways was completed January 8, 1992.

A-2.2 Silo 3 Structural Integrity

Past safety analyses have recognized that the greatest risk from Silo 3 projects involves the catastrophic failure of the structure. Therefore, structural analyses have been performed to determine the probability of failure and to derive controls necessary to ensure that structural integrity is not compromised during project activities. Three such evaluations have been performed on the structural integrity of Silo 3. These analyses are (1) *Metal Oxide and Empty Silo Study & Evaluation Report* (1986) [Ref. 5]; (2) *Silo 1 through 4 Structural Integrity Determination* (1994) [Ref. 6]; and (3) a 1998 Engineering Evaluation, *Silo Dome Design Properties* [Ref. 7].

These studies provided a basis for determining a silo dome safe load limit. Load limits for the Silos are documented in 40000-H&S-0001, *Technical Safety Requirements Document for the Operable Unit 4 (OU4) Silos* [Ref. 8], and are summarized in Section 10.3 of this N-HASP. PCN2

Evaluation of the Silo 3 retrieval and disposition activities design in the PHAR [Ref. 9] concluded there were no safety class (SC) or safety significant (SS) structures, systems or components (SSCs). Therefore a Performance Category 2 (PC-2) was assigned, and the facility was designed and built to uniform building codes. Design and building of PC-2 SSCs to uniform building code will result in only limited structural damage from design basis natural phenomena hazards.

A-2.3 Description Of The Silo 3 Project

Access and retrieval of the Silo 3 material will be accomplished by both pneumatic and mechanical systems [Ref. 10]. Before retrieval, radon concentrations in the silo headspace will be reduced by venting through the Silo 3 stack.

Pneumatic retrieval involves vacuuming material, e.g., through openings in the Silo 3 dome. As a part of dome retrieval, the Pneumatic Retrieval System (PRS) is used to remove material behind the silo wall before creating the wall opening. The PRS then transfers material to the Process Building. These activities are referred to as "Phase 1" of the retrieval process.

In addition to pneumatic retrieval, a Mechanical Retrieval System (MRS) may be used to access and remove the compacted material from Silo 3. In preparation for mechanical retrieval, a reinforced concrete framework will be installed on the silo wall, and a section of the silo wall will be removed. A mechanical excavator transfers Silo 3 material to a bin located in the Excavator Room. Conveyors feed the material to the adjacent Process Building. These activities are referred to as "Phase 2" of the retrieval process.

A Feed Conveyor, located in the Process Building, receives Silo 3 material from the PRS or the MR. The Feed Conveyor discharges material to 2 Package Loading Stands. The material will be conditioned by the addition of a binding agent for dust control and stabilization. The binding agent is a ferrous sulfate and sodium lignosulfonate solution that

will be sprayed into the fill chutes. Each of the two Package Loading Stands is a semi-automated system with loading spouts, loading stands, thumper tables, weighing scales, and motorized roller conveyors for transporting the filled bags away from the station.

After a soft-sided container is filled, the inner PVC liner is sealed by radio frequency, perforated, and detached from the fill chute at the perforation. The container is moved to the Package Staging Conveyor, where swipe sampling and surveys of the container assembly are performed. If no contamination is found, the container is then transported to the Cargo Container Bay, through an airlock, where it is closed and placed on a shipping pallet. The containers are surveyed to meet shipping requirements and staged for labeling. Once a container has been labeled, it will be loaded into an enclosed truck trailer using a forklift, and transported to a staging area for shipment off-site.

The ISA was constructed in the year 2000 east of Silo 3. It is a 9-inch-thick reinforced concrete pad. A portion of the pad may be used for loading the soft-sided containers onto trucks. Another portion is now designated as the Process Building site. The pad has catch basins, an underground storm water drainage system, and aprons to the new infrastructure road.

A-2.4 Safety Basis History And Update

Hazard and accident analyses are performed to identify specific controls and improvements that feed back into overall safety management. Consequence estimates form the bases for grading the level of detail and control needed in specific programs. The result is safety basis documentation that emphasizes controls needed to maintain safe operation of a facility.

Fluor Fernald, Inc. has been responsible for maintaining a single integrated safety basis for all activities in OU4 [Ref. 11]. Safety programs addressing DOE-STD-3009-94, Chapters 6–17, were established and implemented accordingly.

For the final phases of Silo 3, specifically retrieval and disposition of the waste, Fluor Fernald, Inc. has directed the preparation of an N-HASP to document hazards identification, hazard categorization, and accident analysis, as defined in 10 CFR 830 [Ref. 12]. This N-HASP is consistent with the technical position NTSP-2002, *Methodology for Final Characterization for Nuclear Facilities from Category 3 to Radiological* [Ref. 13], issued in 2002 by DOE-EH-53, Office of Nuclear Safety. This paper clarifies DOE-STD-1027 final hazard categorization and applies the methodology to classification below HC-3. This IHA has been prepared to support the NHASP for the Silo 3 operation and maintenance of the retrieval and disposition activities.

A-3.0 METHODOLOGY

This IHA summarizes the hazards of various tasks and subtasks within the Silo 3 Project. The summary tables are presented in SECTION A-4.0 and are labeled as final integrated hazard analysis because they were assessed while the project and activities were in their final stages of design. To ensure that the hazards considered are all-inclusive, subsequent reviews were completed by staff from Fluor Fernald, Inc., and Jacobs representing engineering, project management, and all health and safety disciplines. The health and safety hazards were evaluated to identify all possible hazards that may be encountered within the Silo 3 Project. Additional hazards have been added to the final integrated hazard analysis tables. The final integrated hazard analysis tables have been based on those submitted with the conceptual design and supplemented by the hazards identified during design reviews.

The final integrated hazard analysis processes contained herein are in compliance with the recommended process in NS-0005, *Initiating, Reviewing, and Approving DOE-Approved SBDs* [Ref. 2]. Further information on the process and many other hazard evaluation procedures can be found in *Guidelines for Hazard Evaluation Procedures, Second Edition with Worked Examples* [Ref. 14].

A-3.1 Hazard Identification

All types of hazards were considered and documented, including standard industrial hazards, human capability limitations, health hazards, electrical, energy-release, radiological, biological, toxic and hazardous materials, and natural phenomena. All of the activities were analyzed against a master list of hazards, **TABLE A.3-1**, to decide which were applicable [Ref. 13]. The results of the analysis are presented in this IHA.

The identified hazards were entered into the final integrated hazard analysis tables along with possible causes, potential consequences, and estimated frequency and severity, on the basis of experience and judgment. Controls and mitigators for all hazards were identified. This information was then used to identify safety hazards that require special attention and/or additional analysis. **TABLE A.3-2** contains the criteria for significant hazards as defined in NS-0005, *Initiating, Reviewing, and Approving DOE-Approved SBDs* [Ref. 2]. **TABLE A.3-3** provides the consequence classifications employed for this final integrated hazard analysis. These consequence classifications were selected for inclusion in the final integrated hazard analysis tables under the heading of "severity."

TABLE A.3-1: HAZARD IDENTIFICATION CHECKLIST			
Item	**Hazard**	**Definition**	**Potential Accident/Effect**
1	Acceleration/ Impact	Change in velocity, impact energy of vehicles, components or fluids	1. Structural deformation 2. Breakage by impact 3. Displacement of part or piping 4. Seating or unseating of valves or electrical contacts 5. Loss of fluid pressure head (cavitation) 6. Pressure surges 7. Explosions or detonations
2	Potential Energy/ Elevation	Potential to fall	1. Falling of individuals from elevated locations 2. Falling of elevated objects, striking and injuring people, or damaging structures or equipment 3. Falling attributable to lack of handrails/ladder enclosures that could prevent falls
3	Chemical Energy/ Reactivity	Chemical reactions	1. Fire 2. Explosion/detonation 3. Exothermic reactions 4. Production of toxic/flammable gases
4	Contamination	Introduction of contamination	1. Clogging of mechanical components 2. Friction between moving parts 3. Component degradation 4. Making equipment/structures/ components unusable because of contamination
5	Electrical Energy	Electrical component release or failure, shock	1. Electrocution 2. Involuntary personnel reaction 3. Personnel burns 4. Ignition of combustibles 5. Inadvertent activation of equipment 6. Disabling of electric emergency/safety equipment 7. Interruption of communications
6	Human Capability	Human factors	1. Personnel injury due to lifting too much or improper lifting 2. Personnel injury because of: a. Restricted/excessive hours b. Hazardous location c. Inadequate visual/audible warnings 3. Equipment damage by improper operation because of: a. Inadequate training b. Inaccessible control c. Inadequate control display/identification d. Inadequate procedures
7	Interface Interaction	Compatibility between systems/ subsystems	1. Incompatible materials reaction 2. Interfacing reactions 3. Unintended operations caused by software

TABLE A.3-1: HAZARD IDENTIFICATION CHECKLIST

Item	Hazard	Definition	Potential Accident/Effect
8	Human Hazards	Conditions that can cause human injury	1. Personnel injury because of: a. Sharp edges/corners b. Limited work area 2. Damaged walking/working surfaces that can cause tripping injuries 3. Unguarded equipment
9	Kinetic Energy	System/component linear or rotary motion	1. Linear impact 2. Disintegration of rotating components
10	Material Deformation	Degradation of material by corrosion, aging, embrittlement, or oxidation	1. Change in physical or chemical properties 2. Structural failure 3. Electrical insulation breakdown 4. Erosion of lines or components 5. Component failures 6. Collapse/loss of containment
11	Mechanical Energy	System/component energy	1. Personnel injury/equipment damage from energy release of component such as a spring 2. Personnel injury because of being caught/crushed by moving parts
12	Natural Phenomena	Lightning, high winds, projectiles, earthquakes, floods, tornadoes	1. Structural damage from wind/tornadoes 2. Collapse and loss of containment from earthquakes, wind and tornadoes 3. Electric discharge 4. Dimensional changes from solar heating 5. Personnel injury/death from projectiles 6. Equipment/structural damage from projectiles 7. Personnel injuries/death from flooding 8. Equipment/structural damage from flooding 9. Damage and injuries because of lightning
13	Pressure	System/component energized by high, low, or changing pressure	1. Fragments/noise and pressure pulse from over-pressurized container rupture 2. Line/hose whipping 3. Container implosion 4. System leaks 5. Aeroembolism, bends, choking or shock 6. Deformation because of stress failure
14	Radiation	Radiation exposure and conditions including electro-magnetic, ionizing, thermal, or ultraviolet radiation	1. External exposure 2. Contamination of personnel, equipment, and/or facilities 3. Radon exposure 4. Internal exposure

TABLE A.3-1: HAZARD IDENTIFICATION CHECKLIST

Item	Hazard	Definition	Potential Accident/Effect
15	Thermal	High and low and changing temperature	1. Ignition of combustibles 2. Initiation of other reactions 3. Distortion of parts 4. Expansion/contraction of fluids and solids 5. Liquid compound stratification 6. Personnel injury/stress
16	Toxicants	Adverse human effects of inhalants or ingestation, and adverse effects on biota	1. Respiratory system damage 2. Blood system damage 3. Body organ damage 4. Skin irritation or damage 5. Nervous system effects
17	Biohazards	Adverse human effects	1. Insect sting/bites 2. Histoplasmosis 3. Snake bites
18	Vibration/ Sound	System-/ Component-produced energy	1. Material fatigue 2. Personnel fatigue or injury 3. Pressure/shock wave effects 4. Loosening of parts 5. Chattering of valves or contacts 6. Communication interference 7. Impairment or failure of displays 8. Hearing loss, both acute and long-term
19	Caustic/Acidic	Chemical reactions because of chemical energy	1. Burns 2. Chemical reactions
20	Spill/Loss of Containment	Release of hazardous materials	1. Personnel injury 2. Costly cleanup 3. Damage to components/property 4. Off-site transport of contaminant 5. Environmental or ecosystem damage
21	Industrial/ Construction Hazards	Hazards encountered in industrial work environments, such as confined spaces or welding	1. Personnel injury/death 2. Loss of work/production

TABLE A.3-2: CRITERIA FOR SIGNIFICANT HAZARDS

		Hazard Consequence			
Frequency		Very Low	Low	Moderate	High
Anticipated	$\geq 10^{-2}$/yr				
Unlikely	$\geq 10^{-4}$/yr but $< 10^{-2}$/yr				
Extremely unlikely	$\geq 10^{-6}$/yr but $< 10^{-4}$/yr				
Incredible	$< 10^{-6}$/yr				

The shaded cells in the table indicate frequencies and hazard consequences that are considered significant and require analysis.

TABLE A.3-3: CONSEQUENCE CLASSIFICATION

	Worker Safety[a]	Worker Radiation Exposure	Worker Chemical Exposure[b]	Public Radiation Exposure	Public Chemical Exposure[b,c]	Public Safety
High	Fatalities and/or numerous serious injuries	> 250 rem	ERPG-3	> 25 rem	ERPG-2	> 5 serious injuries
Moderate	1 fatality or > 5 serious injuries	> 5 but < 250 rem	ERPG-2	> 0.5 but < 25 rem	ERPG-1	> 1 but < 5 serious injuries
Low	> 1 but < 5 serious injuries	> 0.5 but < 5 rem	ERPG-1	> 0.01 but < 0.5 rem	PEL-TWA[d]	Minor injury
Very Low	Minor injuries	< 0.5 rem	< ERPG-1	< 0.01 rem and other legal limits on normal emissions	EPA[e] and other legal limits on normal emissions	

[a] For the purposes of this table, a serious injury is defined as one that results in lost time.
[b] Emergency Response Planning Guidelines (ERPG) [Ref. 15].
[c] Threshold Limit Values for Chemical and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists [Ref. 16].
[d] PEL - TWA = permissible exposure level – time-weighted average
[e] EPA = U.S. Environmental Protections Agency

A-3.2 Silo 3 Tasks And Subtasks

The Silo 3 Project tasks and subtasks were defined to provide a logical organization as a function of time and to eliminate redundancy in the final integrated hazard analysis table. The tasks include construction, operation and maintenance, and demobilization. The operation and maintenance tasks were divided into subtasks for each major function of the Silo 3 Project. This feature in the organization eliminates the redundancy in the final integrated hazard analysis tables by negating the need to repeat hazards for each task.

TABLE A.3-4 is a matrix of tasks and subtasks versus hazard types for the Silo 3 Project. The tasks and subtasks described above comprise one axis of the matrix, while the hazard types comprise the other axis. Numbers and letters are entered into the matrix to designate specific hazards that are addressed in the final integrated hazard analysis (TABLE A.4-1). The matrix assists in ensuring that each hazard type is correctly recognized and addressed in the final integrated hazard analysis and in ensuring that the hazards are identified for each task.

The hazards were derived from TABLE A.3-1, the Hazard Identification Checklist, which defines 21 types of hazards according to physical, chemical, and biological properties [Ref. 13]. Each of these hazard types was addressed with respect to the Silo 3 Project to determine applicability. Emphasis was given to the hazards of external and internal exposure to radiation, radioactive contamination, and release of radon gas, because these hazards are a major concern to DOE and the public.

TABLE A.3-4: MATRIX OF TASKS/SUBTASKS VS. HAZARDS FOR SILO 3 FACILITY

HAZARD TYPE	ID Number	STORAGE, S&M	CONSTRUCTION	OPERATION AND MAINTENANCE			DEMOBILIZATION
				Material Retrieval	Process Building Operations	ISA Operations	
Potential/Kinetic Energy							
Drop crane load	2a		X			X	X
Personnel fall from heights	2b	X	X	X	X		X
Drop tools/equipment	2c	X	X	X	X	X	X
Crane load swing	2d		X			X	X
Structural failure of silo due to degraded condition and excessive load	2e	X	X	X	X	X	X
Vehicle crash into facility	2f	X	X	X	X	X	X
Chemical Energy							
Fire/explosion from fuels	3a		X			X	X
Electrical Energy							
Overhead lines	5a		X				X
Utility connection/disconnection	5b		X				X
Hand tools/maintenance	5c	X	X	X	X	X	X
Human Capability and Hazards							
Inadequate lighting	6a	X	X	X	X	X	X
Slips, trips, and falls	6b	X	X	X	X	X	X
Pinch points	6c	X	X	X	X	X	X
Noise	6d	X	X	X	X	X	X
Heat/cold stress	6e	X	X	X	X	X	X
Human error due to clutter	6f	X	X	X	X	X	X
Human error due to equipment layout, human factors, ergonomics	6g			X	X		
Human error due to remote camera failure	6h			X	X		

TABLE A.3-4: MATRIX OF TASKS/SUBTASKS VS. HAZARDS FOR SILO 3 FACILITY

HAZARD TYPE	ID Number	STORAGE, S&M	CONSTRUCTION	OPERATION AND MAINTENANCE			DEMOBILIZATION
				Material Retrieval	Process Building Operations	ISA Operations	
Human Capability and Hazards (cont.)							
Human error due to schedule pressure, communications failure, complicated tasks	6i	X	X	X	X	X	X
Mechanical Energy							
Hand and power tools, rotating/conveying machinery	11a		X	X	X		X
Natural Phenomena							
Lightning, wind, tornado, earthquake	12a	X	X	X	X	X	X
Radiation							
Exposure from Silo 3 material storage	14a	X	X	X	X	X	X
Hose rupture during pneumatic retrieval	14b			X			
Silo wall failure due to wall cutting operations	14c		X	X			
Spill material from conveyor failure	14d			X	X		
Breach of a material storage bag	14e				X	X	
Breach of DOT package in ISA	14f					X	
Dust collector failure	14g			X	X		
Silo collapse from pressure differential	14h			X			
Toxicants							
Concrete burns, paints, chemicals, silica, fuel, oil	16a		X	X	X	X	X
Spill of ferrous sulfate	16b				X		
Chemicals-such as lead and beryllium	16c		X	X	X	X	X
Exhaust from forklift-CO	16d				X	X	

TABLE A.3-4: MATRIX OF TASKS/SUBTASKS VS. HAZARDS FOR SILO 3 FACILITY

HAZARD TYPE	ID Number	STORAGE, S&M	CONSTRUCTION	OPERATION AND MAINTENANCE			DEMOBILIZATION
				Material Retrieval	Process Building Operations	ISA Operations	
Biohazards							
Poison ivy, snakes, bees and insects	17a		X			X	X
Industrial Hazards							
Welding and burning	21a		X				X
Confined space entries	21b		X				X
Traffic–trucks, heavy equipment, people	21c		X			X	X

Note: The final integrated hazard analysis ID numbers designate specific hazards that are addressed in TABLE A..4-1.

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A-4.0 FINAL HAZARD ASSESSMENT TABLE

The hazard selection criteria for the final integrated hazard analysis table have an emphasis on radiological hazards because of the nature of the waste materials. The criteria include:

- worker exposure to physical, chemical, or radiological hazards while performing the identified task or subtask
- spread of radioactive contamination because of inadequate administrative controls
- release of toxic or radiological materials to the atmosphere, ground, or groundwater because of catastrophic failure of an SSC
- health and safety hazards to workers during general construction
- standard industrial hygiene and safety hazards in an industrial facility

The final integrated hazard analysis table, **TABLE A.4-1** is organized as described in SECTION A-3.1 for each task and subtask. The hazard types are the applicable hazards taken from *Hazard Analysis Report for Operable Unit 4 (OU4)*, Appendix B [Ref. 17].

This information was then used to identify safety hazards that require special attention and/or additional analysis. TABLE A.3-2 contains the criteria for significant hazards as defined in NS-0005, *Initiating, Reviewing, and Approving DOE-Approved SBDs* [Ref. 2]. TABLE A.3-3 provides the consequence classifications employed for this final integrated hazard analysis. These consequence classifications were selected for inclusion in the final integrated hazard analysis tables under the heading of "severity."

The frequency and severity of the unmitigated hazard consequence are listed in the final integrated hazard analysis table. If the intersection of the hazard consequence and the hazard frequency falls within the cross-hatched area of TABLE A.3-2, the hazard is designated as a significant hazard and the column is marked "Yes." If the intersection is outside the cross-hatched area, the hazard is not designated a significant hazard and the column is marked "No." Standard industrial hazards are marked "SIH."

TABLE A.4-1: FINAL HAZARD ASSESSMENT FOR THE SILO 3 PROJECT

ID No.	Hazard Type	Initiating Event	Consequence (Unmitigated)	SIH * Yes/No	Frequency	Severity	Significant Hazard	Comments, Mitigators, Controls, Actions, and/or Justification
2a	Drop crane load during construction, container handling, or demobilization	Crane lifts	Personnel injury, equipment damage	Y	-	-	SIH	Qualified riggers and equipment operators. Inspect rigging. Uses approved procedures. Appropriate approval for critical lifts. A dropped load over the silo is addressed in ID No. 2e. A spilled container is addressed in ID No. 14f.
2b	Crane load swing	Crane lifts	Personnel injury, equipment or facility damage	Y	-	-	SIH	Qualified riggers and equipment operators. Inspect rigging. Uses approved procedures. Appropriate approval for critical lifts.
2c	Drop tools/ equipment	Working at heights	Personnel injury	Y	-	-	SIH	Hard hats, safety nets or tie off of tools as necessary.
2d	Personnel fall	Working at heights	Personnel injury or fatality	Y	-	-	SIH	Fall protection when working at heights >6 ft, personnel training, PPE, barriers.
2e	Structural failure of silo due to degraded structural condition	Drop load, excessive load, or earthquake	Release of radioactivity	N	Anticipated	Moderate	Yes	Based on the uncertainty in the structural integrity, the life expectancy cannot be determined. Therefore, failure is anticipated. Consequence analysis performed in the PHAR [Ref. 9]
2f	Vehicle crash into facility	Vehicle traffic in immediate area	Release of radioactivity	N	Anticipated	Very Low	No	Work sequencing, traffic control, and training.

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TABLE A.4-1: FINAL HAZARD ASSESSMENT FOR THE SILO 3 PROJECT

ID No.	Hazard Type	Initiating Event	Consequence (Unmitigated)	SIH * Yes/No	Frequency	Severity	Significant Hazard	Comments, Mitigators, Controls, Actions, and/or Justification
3a	Fire	Fuel storage and use, or ignition source	Damage to equipment and facilities. Personnel burns and injury.	Y	-	-	SIH	Storage in accordance with NFPA. Minimize combustibles. Fire protection program.
3a	Fire/explosion	Propane explosion around packaged material	Release of radioactivity	N	Incredible	Low	No	LEL for propane cannot be achieved in area. Storage in accordance with NFPA.
5a	Electric shock	Strike overhead power lines with equipment	Electrocution, burns, shock	Y	-	-	SIH	Maintain minimum distance per OSHA.
5b	Electric shock	Install or disconnect electric power	Electrocution, burns, shock	Y	-	-	SIH	Qualified electrical workers, lockout/tagout program, proper tools
5c	Electric shock	Use of hand tools, maintenance	Electrocution, burns, shock, or fatality	Y	-	-	SIH	Qualified electrical workers, lockout/tagout program, proper tools, use ground fault interrupters
6a	Impaired vision	Inadequate lighting	Personnel injury	Y	-	-	SIH	Human factors review of facility design, provide adequate temporary lighting, per OSHA, for construction and D&D.
6b	Slips and trips	Icy surface, uneven working surface, poor housekeeping	Personnel injury	Y	-	-	SIH	Housekeeping to minimize clutter and ice, sturdy work shoes, design reviews to ensure adequate surfaces.

TABLE A.4-1: FINAL HAZARD ASSESSMENT FOR THE SILO 3 PROJECT

ID No.	Hazard Type	Initiating Event	Consequence (Unmitigated)	SIH * Yes/No	Frequency	Severity	Significant Hazard	Comments, Mitigators, Controls, Actions, and/or Justification
6c	Pinch points	Material handling	Personnel injury	Y	-	-	SIH	Wear work gloves when appropriate, equipment guards, training.
6d	Noise	Work around heavy equipment, process equipment	Hearing loss	Y	-	-	SIH	Noise monitoring, post areas, use hearing protection, enclose noise source, noise isolation.
6e	Heat or cold stress	Weather, work in PPE	Heat- and cold-stress-related injuries	Y	-	-	SIH	Monitor for heat and cold stress during work activities. Wear proper clothing when possible. Uses breaks and fluids, as needed.
6f	Human error	Work around clutter	Personnel injury	Y	-	-	SIH	Housekeeping
6g	Human operations error	Work with inadequate equipment, valve, or controls layout. Inadequate ergonomics	Personnel injury, equipment damage	Y	-	-	SIH	Human factors review of layout, programming, and ergonomics. Training on hierarchy of process controls.
6h	Human operations error	Remote camera failure	Mishandle material, personnel injury	N	Unlikely	Very low	No	Design of remote camera system, mockup testing, backup visual methods where possible.
6i	Human error	Schedule pressure, communication failure, complicated tasks	Personnel injury	Y	-	-	SIH	Training, procedures. Appropriate work schedule.

TABLE A.4-1: FINAL HAZARD ASSESSMENT FOR THE SILO 3 PROJECT

ID No.	Hazard Type	Initiating Event	Consequence (Unmitigated)	SIH * Yes/No	Frequency	Severity	Significant Hazard	Comments, Mitigators, Controls, Actions, and/or Justification
11a	Rotating energy	Use of hand and power tools, motors	Personnel injury	Y	-	-	SIH	Qualified workers, training, guards where possible.
12a	Natural phenomena	High winds, tornadoes, lightning, earthquake	Personnel injury, equipment damage	Y	-	-	SIH	Monitor weather, take cover when weather threatens. Silo failure due to earthquake addressed in ID No. 2e. Retrieval and disposition facility designed and built to uniform building codes.
14a	External radiation exposure	Work near the Silo 3 material storage areas	Potential to exceed dose limits	N	Anticipated	Very Low	No	TLDs and RWPs as required by 10 CFR 835
14b	Radiation exposure	Hose rupture during pneumatic retrieval	Potential to exceed dose limits	N	Anticipated	Low	Yes	Approved procedures, training, process and equipment design, structure over work area.
14c	Radiation exposure	Silo wall cutting operations and subsequent structural collapse	Potential to exceed dose limits	N	Anticipated	Low	Yes	Approved procedures, training, process and equipment design, structure over work area.
14d	Radiation exposure	Spill material due to a conveyor failure	Potential to exceed dose limits	N	Anticipated	Low	Yes	Approved procedures, training, process and equipment design, structure over work area.
14e	Radiation exposure	Breach of a material storage bag	Potential to exceed dose limits	N	Anticipated	Low	Yes	Approved procedures, training, process and equipment design, structure over work area.

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TABLE A.4-1: FINAL HAZARD ASSESSMENT FOR THE SILO 3 PROJECT

ID No.	Hazard Type	Initiating Event	Consequence (Unmitigated)	SIH * Yes/No	Frequency	Severity	Significant Hazard	Comments, Mitigators, Controls, Actions, and/or Justification
14f	Radiation exposure	Breach of a DOT package in ISA	Potential to exceed dose limits	N	Anticipated	Low	Yes	DOT approved package. Approved procedures, training, process and equipment design.
14g	Radiation exposure	Dust collector failure	Potential to exceed dose limits	N	Anticipated	Low	Yes	Approved procedures, training, process and equipment design.
14h	Radiation exposure	Silo pressurization of depressurization and collapse during pneumatic retrieval	Potential to exceed dose limits	N	Depressur-ization Anticipated Pressur-ization Extremely Unlikely	Low	Yes	Approved procedures, operator training, process and equipment design, and structure over silo. Silo pressurization is mitigated by the maximum achievable pressure, which is within failure limits and by the relief valves. Depressurization requires multiple failures and could result in a pressure differential exceeding failure limits.
16a	Exposure to toxic materials	Use of concrete, paints, chemicals, fuel, oil, silica	Skin irritation, respiratory system damage, or other physical effects	Y	-	-	SIH	Use appropriate PPE, MSDS.
16b	Exposure to toxic materials	Spill of ferrous sulfate	Skin irritation, respiratory system damage, or other physical effects	N	Anticipated	Low	Yes	Approved procedures, training, equipment design, use appropriate PPE.

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TABLE A.4-1: FINAL HAZARD ASSESSMENT FOR THE SILO 3 PROJECT

ID No.	Hazard Type	Initiating Event	Consequence (Unmitigated)	SIH * Yes/No	Frequency	Severity	Significant Hazard	Comments, Mitigators, Controls, Actions, and/or Justification
16c	Exposure to chemicals such as lead and beryllium	Spill or release of Silo 3 material.	Personnel injury	Y			SIH	Use appropriate PPE, approved procedures, equipment design.
16d	Exposure to exhaust from forklift-CO	Poor work practice	Personnel injury	Y			SIH	Maintain forklifts properly, approved procedures
17a	Exposure to poison ivy, snake bites, insect stings	Work outdoors	Personnel injury	Y	-	-	SIH	PPE, repellants. Removal of potential hazards (snakes, ivy, etc.)
21a	Exposure to welding operations	Welding and torch cutting	Eye injury, burns, respiratory, fire	Y	-	-	SIH	Training, qualified welders, PPE, fire watch
21b	Confined space	Construction, maintenance, operations, inspections requiring confined space entry	Asphyxiation, injury, or death	Y	-	-	SIH	Training, PPE, ventilation, retrieval and rescue provisions
21c	Traffic	Material delivery, transport, construction, demolition	Personnel injury, equipment damage	Y	-	-	SIH	Observe speed limits; establish/maintain appropriate traffic patterns, traffic control devices, warning equipment, and backup warning devices.

*SIH = standard industrial hazards, Y = yes, N = no
CFR = *Code of Federal Regulations*
D&D = decontamination and decommissioning
MSDS = Material Safety Data Sheets
NFPA = National Fire Protection Association
OSHA = Occupational Safety and Health Administration
PPE = personal protective equipment
RWP = radiological work permit
TLD = thermoluminescent dosimeter

A-5.0 CONCLUSIONS OF THE FINAL INTEGRATED HAZARD ANALYSIS

The final integrated hazard analysis table was analyzed to identify any significant concerns that require further analysis. Most of the potential hazards were found to be anticipated accidents with very low consequences. However, some potential hazards were found to be significant and are discussed in the following sections.

A-5.1 Analysis Of Final Integrated Hazard Analysis Table

The methodology described in SECTION A-3.0 and represented in TABLE A.3-1 was used to assess the hazards in TABLE A.4-1. All the potential hazards were anticipated or unlikely accidents with very low consequences. The following exceptions are significant hazards that require further analysis:

- Structural failure of silo due to a dropped load, excessive load, or earthquake
- Hose rupture during pneumatic retrieval
- Silo wall failure due to wall cutting operations
- Spill material due to a conveyor failure
- Breach of a material storage bag
- Dust collector failure
- Silo depressurization and collapse
- Spill of ferrous sulfate
- Breach of a DOT package in ISA

The frequency and severity of the standard industrial hazards are not specified in TABLE A.4-1, which is consistent with the *Hazard Analysis Report for Operable Unit 4 (OU4)*, Appendix B [Ref. 17]. However, some standard industrial hazards with unlikely frequency may have significant consequences and these hazards warrant some additional consideration. Electrical energy, confined space, and potential energy or elevation hazards have an unlikely frequency and moderately severe consequences, including the possibility of death. The consequence of contact with electrical sources may be a fatal electrocution. The consequence of working in a confined space may be a fatal asphyxiation. The consequence of working at elevated heights may be a fatal fall.

A-5.2 Resolution Of Concerns

The need for a comprehensive health and safety program for the Silo 3 Project is clearly recognized. Health and safety specialists were assigned to review the design process and evaluate the potential hazards. The health and safety specialists worked directly with the designers and were active participants in design review meetings and formal design review processes. Jacobs is committed to a rigorous environmental, health, and safety program for the Silo 3 Project. A strong, comprehensive health and safety program minimizes the frequency of accidents.

The hazard of working with energized electrical power sources is rigorously controlled at FCP by energy isolation plans, service interruption permits, and formal lock-out/tag-out procedures [Refs. 18 and 19]. Entry into confined spaces is rigorously controlled by formal evaluations by FCP industrial hygiene staff and confined space entry permits [Ref. 20]. Working at elevated heights (higher than 6 ft) is rigorously controlled by the FCP fall protection program, which requires harnesses, lanyards, and anchor points in accordance with Occupational Safety and Health Administration standards [Ref. 21].

Potential accidents with significant consequences are concerns that were continuously addressed throughout the design cycle. The results of the final integrated hazard analysis were used in selecting the particular accident scenarios analyzed, which allows the determination of any safety SSCs.

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20. SPR12-1, *Permit-Required Confined Space Entry*, in RM-0021, *Safety Performance Requirements (SPR) Manual*, Fluor Fernald

21. SPR3-1, *Fall Protection and Prevention*, in RM-0021, *Safety Performance Requirements (SPR) Manual*, Fluor Fernald

Appendix B

APPENDIX B
HAZARD CATEGORY CALCULATION

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ACRONYMS

ARF = Airborne release fraction
CEDE = Committed effective dose equivalent
CFR = Code of Federal Regulations
Ci = Curie
DCF = Dose conversion factor
DOE = U.S. Department of Energy
DOT = U.S. Department of Transportation
DR = Damage ratio
EPA = U.S. Environmental Protection Agency
ERPG = Emergency Response Planning Guide
HC = Hazard category
IHA = Integrated Hazard Analysis
ISA = Interim Storage Area
LPF = Leak path factor
MAR = Material at risk
OSHA = Occupational Safety and Health Administration
OU = Operable unit
pCi = Picocurie
PRI = Potentially releasable inventory
RF = Respirable fraction
RQ = Reportable quantity
STD = Standard
TEDE = Total effective dose equivalent
TPQ = Threshold planning quantity
TQ = Threshold quantity
UCL = Upper confidence level

EXECUTIVE SUMMARY

The Silo 3 Retrieval and Disposition Facility is classified as a Radiological (RAD) facility with Low chemical hazards, since the largest potentially releasable inventory does not result in significant localized consequences, due to the low specific activity of the material.

The most severe radiological and chemical hazards from the Integrated Hazards Analysis (IHA), Appendix A, were selected for modeling to determine the hazard category. Several scenarios were analyzed for consequences and the most significant potentially releasable inventory is a result of a silo failure during wall cutting.

The RAD hazard classification was determined after analyzing both radiological and chemical hazards. This is shown in Section B-3.0.

The radiological analysis considered three parameters, total activity of the various radionuclides, total activity that could be reasonably released via bounding scenario, and dose to onsite and offsite personnel.

The chemical analysis considered two parameters, the quantities of the various hazardous chemicals present, and the concentrations that would be generated during the bounding accident. Whereas five hazardous chemicals could be released in quantities exceeding the corresponding Threshold Planning Quantities, the airborne concentrations that would result are lower than the applicable Emergency Response Planning Guides. This is because of the low concentrations of the hazardous components in the bulk material. The "Low" chemical hazard category specified is conservative.

B-1.0 INTRODUCTION

The purpose of this hazard categorization is to ensure that the appropriate level of hazard baseline documentation and approval authority is assigned to the project based on the severity of the hazards that may be encountered.

This document establishes the hazard category designation for the Silo 3 facility in accordance with DOE-STD-1027-92 [Ref. 1] for the following activities:

- Retrieval of material from Silo 3
- Packaging of the material in storage bags for placement into cargo containers
- Storage of cargo containers that are awaiting shipment

The hazard baseline for the activities preceding retrieval has been documented separately in RMR-0445-0056-002, the Silo 3 PHAR [Ref. 2]:

- Continued storage of material in Silo 3
- Routine maintenance and upkeep of Silo 3, support equipment, and surrounding grounds
- Continued design, procurement, construction, and system operability testing of new facilities and/or existing facilities in support of Silo 3 final remediation

B-1.1 Previous Analyses

The preliminary hazard category for Silo 3 storage was first documented in FEMP-2337, *Preliminary Safety Analysis Report (PSAR) for Operable Unit 4* [Ref. 3]. The preliminary hazard categorization of HC-2 was determined by comparing the total inventory of Silo 3 radioactive materials to the threshold quantities listed in DOE-STD-1027-92 [Ref. 4]. In accordance with DOE-STD-1027-92, the PSAR established the final hazard category for Silo 3 as HC-3, based on the hazards analysis.

Subsequent safety basis documents continued to document Silo 3 storage as HC-3, including the *Hazards Analysis Report (HAR) for Operable Unit* 4 [Ref. 5], and the *Preliminary Hazard Analysis Report for Silo* 3 [Ref. 2].

B-1.2 Segmentation

The Silo 3 structure houses the entire inventory of hazardous materials associated with current Silo 3 activities, processes, and operations. Therefore, the "facility" considered for hazard categorization is limited to the Silo 3 structure and its contents. The concept of independent facility segments is applied *within* a facility where facility features preclude bringing hazardous materials together or causing harmful interaction from a common severe phenomenon. Therefore, the Silo 3 structure constitutes a single segment, authorized by the PHAR.

The Hazard Category Calculation documented here establishes that the Silo 3 Retrieval and Disposition Project consists of two additional segments with respect to safety analysis for future project configurations. Therefore, there are a total of three facility segments:

1. Silo 3 - analyzed and authorized in PHAR
2. Process Building - analyzed and authorized in this N-HASP
3. Interim Storage Area (ISA) - analyzed and authorized in this N-HASP

The Process Building consists of a process area containing material handling and bag-out facilities, the Excavator Room, the Excavator Service Room, and the Cargo Container Bay. The building is adjacent to Silo 3, and connects to Silo 3 through the batch type retrieval mechanisms (pneumatic and mechanical). After construction of the building and operation of the pneumatic retrieval system for initial removal of waste material, an opening will be cut in the silo to provide direct access to the remaining contents by mechanical retrieval

from the Excavator Room [Ref. 6]. The ISA pad will be used for storage of filled cargo containers awaiting shipment.

B-1.3 Bounding Accidents

The most severe radiological and chemical hazards from the IHA, Appendix A, were selected for modeling the potentially releasable inventory to determine the HC. These hazards were identified as significant based on the frequency of occurrence and consequences. The hazards are listed in **TABLE B.1-1**.

Silo structural failure during cutting a wall opening is analyzed as EBA-2 in Appendix G of this N-HASP.

For the Process Building, four accidents were analyzed, all with relatively low consequences. They included hose rupture (EBA-1 in Appendix G), spill from conveyor (EBA-3 in Appendix G), bag breach (EBA-4 in Appendix G), and filter failure (EBA-5 in Appendix G).

The ISA will contain only material in sealed bags, which qualify as DOT approved shipping containers, authorized by the package Test Plan [Ref. 7]. Therefore, in this segment, no scenarios for release were modeled.

TABLE B.1-1: BOUNDING HAZARDS FROM THE INTEGRATED HAZARD ANALYSIS

Segment Item	IHA Table ID	Potential Accident	Potential Releasable Inventory	Event Selected for Further Evaluation in Appendices B and G
A4	14c	Silo containment failure while cutting silo wall opening	Loss of complete radon inventory plus radon emanating over a 24-hour period and one percent of the impacted solids	Yes, most significant unanalyzed event, modeled as EBA-2 in Appendix G.
A5	14h	Silo depressurization and dome collapse during pneumatic retrieval	Loss of complete radon inventory plus radon emanating over a 24-hour period and less than one percent of the impacted solids	No, consequences will not exceed EBA-2 in Appendix G. However, prevention must be considered.
B1	14b	Hose rupture during pneumatic retrieval operations	Loss of complete radon inventory plus radon emanating over a 24-hour period and solids in the vacuum extractor line	Yes, modeled as EBA-1 in Appendix G.
B2	14d	Spill of material from conveyor failure	Solids and radon in equipment in operation after failure. 24-hour radon emanation from release of solids	Yes, modeled as EBA-3 in Appendix G.
B3	14e	Package failure during transport to cargo container	Solids and radon in package plus 24-hour radon emanation from released solids	Yes, modeled as EBA-4 in Appendix G.
B4	14g	Filter system failure during retrieval operations	Solids and radon released during operation after failure	Yes, modeled as EBA-5 in Appendix G.
C1	14f	Material spill on ISA pad	Material spill results on the ISA pad.	No, bags are DOT containers. However, verification of DOT status must occur before transfer of package to ISA

B-1.4 Hazard Categorization Existing Conditions

10 CFR 830, Subpart B, *Safety Basis Requirements* [Ref. 8], requires facility categorization based on associated nuclear hazards. Specifically, the hazard categorization process establishes the thresholds above which 10 CFR 830, Subpart B are relevant and applicable. As stated in §830.202 (b) (3), contractors responsible for DOE nuclear facilities are required to categorize each facility based on its potential hazards, using methodology consistent with DOE-STD-1027-92 [Ref. 4]. The scope identified in §830.200 specifies that the safety basis requirements identified in 10 CFR 830, Subpart B, are applicable to Hazard Category 1, 2, and 3 DOE nuclear facilities.

10 CFR 830 defines a facility as HC-2 if the hazard analysis shows "...the potential for significant on-site consequences beyond localized consequences." DOE-STD-1027-92 further interprets the HC-2 categorization as applicable to:

> *Facilities with a potential for nuclear criticality events or with sufficient quantities of hazardous material and energy, which would require on-site emergency planning activities.*

Table 1 of 10 CFR 830 defines a facility as HC-3 if the hazard analysis shows "...the potential for only local significant consequences." DOE-STD-1027-92 further interprets the HC-3 categorization as applicable to:

> *Facilities with quantities of hazardous radioactive materials which meet or exceed Table A.1 values (Attachment 1 of DOE-STD-1027-92).*

Provisions have also been made that allow for the final hazard categorization of a nonreactor nuclear facility to be based on safety analysis rather than inventory comparison. This final hazard categorization may take into account material form and potential dispersiveness, lack of available energy sources, or accident credibility.

Hazard categorization for Silo 3 Retrieval and Disposition is consistent with the technical position NSTP-2002-2, *Methodology for Final Categorization for Nuclear Facilities from Category 3 to Radiological* issued in 2002 by DOE-EH-53, Office of Nuclear Safety [Ref. 9]. This paper clarifies DOE-STD-1027 final hazard categorization and applies the methodology to classification below HC-3. It states:

> *The HC-3 threshold values for radionuclides for which the food pathway or the inhalation pathway are limiting may be revised if, based on the physical and chemical form and available dispersive energy source for the facility and its hazardous materials, the credible release fractions (airborne release fractions) can be shown to be significantly different than the values used in the EPA Technical Background Document.*

Therefore, an activity can be categorized less than HC-3 if a safety analysis (accident analysis) demonstrates that, for a credible unmitigated release, a potential for significant localized consequences does not exist. In this context, "unmitigated" is meant to consider material quantity, form, location, depressiveness, and interaction, but is not meant to consider designed facility safety features (i.e., ventilation, fire suppression, etc.).

On this basis, the purpose of this Hazard Category Calculation is to determine if, due to Silo 3 retrieval and packaging operations, a credible accident scenario exists which has a risk of causing significant localized consequences.

B-2.0 DESCRIPTION OF HAZARDS

B-2.1 Radioactive Materials Inventory

The concentrations (pCi/g) of radionuclides found in Silo 3 material are shown in **TABLE B.2-1**. The radionuclide inventories are derived from the specific activity results obtained from the core sampling of Silo 3, which are tabulated in Table 4-2 of the *Remedial Investigation Report for OU4* [Ref. 10].

Silo 3 contains U-238, U-235 and Th-232 radionuclides and their daughter products (daughter products with half-lives of less than one hour are not included;...→ denotes other short-lived radionuclides in the chain), as indicated below:

U-238 ... → U-234 → Th-230 → Ra-226 → Pb-210

U-235 ... → Pa-231 → Ac-227

Th-232 → Ra-228 ... → Th-228 → Ra-224

The 95 percent upper confidence limit (UCL) concentrations of 12 radionuclides in the Silo 3 material are taken from Table 4-1 ("Summary of Radionuclide Analysis for Silo 3 Material") from the *Remedial Investigation Report for OU4* [Ref. 10]. A 13th radionuclide, U-236, is included because the analytical results report U-235/U-236 together. U-236 is a daughter product of Pu-240 and does not routinely occur in nature. This hazard category calculation assumes the reported activity in this case is U-235. Other radionuclides in the U-238, U-235, and Th-232 series including the short-lived daughters are also considered for categorization. The length of time for these radionuclides to reach secular equilibrium ranges from 30 to 100 years. The short-lived daughter products in each series are considered to be in secular equilibrium with their parents. Daughter nuclide concentrations vary by only a few percent over this range. In the case where analytical results do not agree with equilibrium calculations, the more conservative values (larger values typically from equilibrium calculations) are used for daughter product concentrations. The radionuclide concentrations are shown in Table B.2.1 and the total activity concentration of all radionuclides is calculated to be 97.4 nCi/g. The short-lived daughters not listed in Table B.2.1 include Po-218, Rn-219, Po-215, Bi-211, Tl-207, Po-216, Po-212, and Tl-208.

The Remedial Investigation conducted for Silo 3 reports that the silo contains approximately 5,088 yd^3 of residue, ranging in material density from 29 to 58 lb/ft^3. Based on the maximum estimated density, the available silo material weighs a maximum of 3,993 tons (7.99 x 10^6 lb.). The total activity of all the radionuclides is calculated as 370 Ci, as shown in Table B.2.1.

The Process Building and Cargo Container Bay inventory is estimated based on the material volumes in the various stages of retrieval and packaging, which is approximately 2,693 cf. During pneumatic retrieval, material is present in the Pneumatic Retrieval Collector, Cartridge Filter, Discharge Feeder, Feed Conveyor, and Packaging System. During mechanical retrieval, material is present in the Retrieval Bin, Inclined Conveyor,

Transfer Conveyor, Feed Conveyor, and Packaging System. It is assumed that up to 16 full bags are in the Cargo Container Bay, which comprises the majority of the building inventory. Material is also present in the Process Vent Dust Collectors. Based on the maximum density, the silo material inventory in the Process Building and Cargo Container Bay is approximately 134,650 lb, or 7.25 Ci.

TABLE B.2-1: SILO 3 RADIOACTIVE MATERIAL INVENTORIES

Radio-nuclide	Silo 3 Activity Concentrations (pCi/g)	Silo 3 Radionuclide Inventory (Ci)	Building Inventory (Ci)
Ac-227	925	3.4	6.66E-02
Ac-228	406	1.5	2.94E-02
Bi-210	3,480	12.6	2.47E-01
Bi-212	367	1.3	2.55E-02
Bi-214	3,870	14.0	2.74E-01
Fr-223	13	0.0	0.00E+00
Pb-210	3,480	12.6	2.47E-01
Pb-211	925	3.4	6.66E-02
Pb-212	367	1.3	2.55E-02
Pb-214	3,870	14.0	2.74E-01
Po-210	3,480	12.6	2.47E-01
Pa-231	627	2.3	4.51E-02
Pa-234	2	0.0	0.00E+00
Pa-234m	1,778	6.4	1.25E-01
Ra-223	925	3.4	6.66E-02
Ra-224	367	1.3	2.55E-02
Ra-226	3,870	14.0	2.74E-01
Ra-228	406	1.5	2.94E-02
Th-227	925	3.4	6.66E-02
Th-228	747	2.7	5.29E-02
Th-230	60,200	218.3	4.28E+00
Th-231	117	0.4	7.84E-03
Th-232	842	3.1	6.08E-02
Th-234	1,780	6.5	1.27E-01
U-234	1,730	6.3	1.23E-01
U-235/236	117	0.4	7.84E-03
U-238	1,780	6.5	1.27E-01
Rn-220	838	3.0	5.88E-02
Rn-222	3870	14.0	2.74E-01
Total (Ci)	**97,400**	370	7.25E+00
Mass (lbs)		7,986,600	134,650
Volume (cf)		137,400	2,693

B.2.2 Chemical Inventories

Chemical constituents are present in the Silo 3 material. In addition, process chemicals will be brought into the facility.

B.2.2.1 Silo 3 Waste

A total of 22 metals have been identified in the chemical composition of this waste. Previous analyses indicate that the material contains up to 15 percent sulfate and has undergone calcination in temperatures up to 820°C (1,500°F). At this temperature, elements are chemically bonded with their sulfate and oxide compounds. If the sulfate is not stable, it will convert into oxide and sulfur dioxide (gas). Any volatile organic compounds (VOC) present would have completely decomposed during calcination.

Silo 3 elemental concentrations (mg/kg) are shown in Table B.2.2. These concentrations are converted into potentially releasable inventory (PRI) for comparison to thresholds. The PRI assumes 3,993 tons of Silo 3 material and an estimated damage ratio of 5.5%, which is material release determined for the earthquake silo failure in the Auditable Safety Record.

No compounds listed in 29 CFR 1910.119 [Ref. 11] are contained in the Silo 3 waste material. The potential chemical compounds are compared against the Reportable Quantities (RQs) in 40 CFR Part 302.4 [Ref. 12] for a preliminary hazard screening. The results of this comparison indicate eighteen chemical compounds may be present in inventories exceeding the RQ values. Moreover, of the chemical compounds, five compounds exceed threshold planning quantity (TPQ) values established in 40 CFR 355 [Ref. 13], as shown in TABLE B.2-2.

Materials released in excess of the reportable quantity are of regulatory concern. In addition, these compounds are toxic and of a health concern from OSHA and American Conference of Governmental Industrial Hygienists (ACGIH) [Ref. 14] points of view and must be given proper consideration during the development of the project-specific health and safety plan.

The 40 CFR 355 TPQ values are listed for the compounds of five metals, arsenic, cadmium, mercury, thallium, and vanadium. Based on this comparison, compounds for all these five elements are above the TPQ values, for the catastrophic silo failure. These compounds are vanadium pentoxide, arsenic trioxide, cadmium oxide, mercuric oxide, and thallium sulfate.

There are no values listed for the remaining 17 elements as sulfates or oxides. Concentrations of vanadium pentoxide, arsenic trioxide, cadmium oxide, mercuric oxide, and thallium sulfate are assessed in the accident analyses to determine if significant localized consequences are possible.

TABLE B.2-2: INVENTORY OF INORGANIC CHEMICALS

Inorganic Chemical	Concen-tration[a] (mg/kg)	Total Elemental Mass[b] (kg)	Potentially Releasable Inventory[c] (kg)	Table 40 CFR 302.4			40 CFR 355	
				RQ[d] (kg)	Applicable Chemical Compound[e]	Exceed RQ	TPQ[d] (kg)	Exceed TPQ
Aluminum	29,500	106,965	5,883	2,270	Aluminum sulfate	Yes	n.l.	
Arsenic	7,270	26,360	1,450	0.454	Arsenic trioxide	Yes	45.4	Yes
Barium	570	2070	11	Not listed			n.l.	
Beryllium	92	333	18	4.54	Beryllium powder	Yes	n.l.	
Cadmium	343	1,244	68	0.454	Cadmium oxide	Yes	45.4	Yes
Calcium	57,500	208,490	11,467	Not listed			n.l.	
Chromium	823	2,984	164	Not listed			n.l.	
Cobalt	6,280	22,771	1,252	Not listed			n.l.	
Copper	7,360	26,687	1,468	4.54	Copper sulfate	Yes	n.l.	
Iron	113,000	409,729	22,535	454	Ferric sulfate	Yes	n.l.	
Lead	6,800	24,656	1,356	4.54	Lead sulfate	Yes	n.l.	
Magnesium	120,000	435,110	23,931	Not listed			n.l.	
Manganese	13,200	47,862	2,632	Not listed			n.l.	
Mercury	1,740	6,309	347	4.54	Mercuric sulfate	Yes	n.l.	
		35,860	1,972	0.454	Mercuric oxide	Yes	227	Yes
Nickel	9,890	287,173	15,794	45.4	Nickel sulfate	Yes	n.l.	
Potassium	79,200	3,271	180	Not listed			n.l.	
Selenium	902	3,013	166	4.54	Selenium dioxide	Yes	n.l.	
Silver	831	333,947	18,367	Not listed			n.l.	
Sodium	92,100	591	33	Not listed			n.l.	
Thallium	163	39,522	2,174	45.4	Thallium oxide or sulfate	Yes	45.4	Yes
Vanadium	10,900	3,078	169	454	Vanadium pentoxide	No	45.4	Yes
Zinc	849	106,965	5,883	454	Zinc sulfate	No	n.l.	

[a]The 95th percentile concentrations are taken from WSRC-TR-2000-00523, Appendix 3 [Ref. 15].
[b]Total Elemental Mass (kg) = Concentration (mg/kg) x 3,993 tons material x 908 kg/ton x kg/10^6mg
[c]Potentially Releasable Inventory (kg) = Total Elemental Mass x Damage Ratio of 5.5%
[d]RQ is taken from Table 40 CFR 302.4 (Final RQ); TPQ taken from 40 CFR 355, Appendix A
[e]Sulfate or oxide compound assumed based on process chemistry (beryllium powder assumed here for conservatism)

B-2.2.2 Process Chemicals

In addition to the chemical constituents in the waste, process chemicals are brought into the Process Building. The Silo 3 materials will be pretreated with sodium lignosulfonate solution. The solution is a polymeric organic binder, which is 47–weight percent sodium lignosulfonate. The solution is a lignin waste product of pulp and paper processing; it is dark brown with a characteristic vanilla-like odor.

The solution will be delivered in 275 gal. containers. One container will be staged in the Cargo Container Bay and 30 gal/day will be used. The inventory is estimated to be approximately 300 gal. sodium lignosulfonate is not listed in 40 CFR 355 or 40 CFR 302.4.

Ferrous sulfate will also be used in the pretreatment. A 4,500 gal storage tank is located in the Cargo Container Bay and 340 gal. will typically be present in the wastewater tank area. The 40 CFR 302.4 RQ is 1,000 lb; therefore, the inventory exceeds the RQ. Ferrous sulfate is not listed in 40 CFR 355. Ferrous sulfate has irritating fumes, and must be stored in a cool, dry, ventilated area.

B-3.0 HAZARD CATEGORIZATION CALCULATIONS

Hazard categorization is dependent upon nonstandard hazards (such as chemical or radionuclide releases), and the short-term exposure to a nearby human receptor.

Preliminary hazard categorization compares total inventory to DOE-STD-1027-92 limits. Final hazard categorization is then based on analysis of specific accident dose consequences to determine if significant localized consequences are possible, taking into account physical and chemical forms of the material, available energy sources, and credible release properties.

The final hazard categorization determination for Silo 3 retrieval and disposition activities used site-specific parameters for comparison to dose criteria to demonstrate whether significant localized consequences are possible.

For chemical hazards, the potentially releasable chemical inventory is compared to the 40 CFR 302 reportable quantity values and the 40 CFR 355 threshold planning quantities. Once it is determined that the threshold values have been exceeded, an evaluation of the consequence severity from those chemicals is performed by comparing accident concentrations to Emergency Response Planning Guide (ERPG) limits.

B-3.1 Preliminary Hazard Categorization

The preliminary hazard categorization is based on comparing the total inventory in each segment to the values listed in DOE-STD-1027-92, Attachment 1, Table A.1. The amount of Silo 3 material inventory required to exceed the HC-3 threshold is 0.7 curies. Therefore, the preliminary categorization of the Process Building, which contains up to 5.64 curies, is HC-3 (see **TABLE B.3-1**).

TABLE B.3-1: PRELIMINARY HAZARD CATEGORIZATION

Radionuclide	Silo 3 Radionuclide Inventory (Ci)	HC-3 Threshold (Ci)	HC-2 Threshold (Ci)	Fraction of HC-3 Threshold	Fraction of HC-2 Threshold
Ac-227	3.4	0.042	4	7.99E+01	7.80E-01
Ac-228	1.5	940	430,000	1.57E-03	3.42E-06
Bi-210	12.6	320	150,000	3.94E-02	8.41E-05
Bi-212	1.3	2,000	430,000	6.65E-04	3.09E-06
Bi-214	14.0	8,200	430,000	1.71E-03	3.26E-05
Fr-223	0.0	8,200	430,000	5.75E-06	1.10E-07
Pb-210	12.6	0.36	2,200	3.51E+01	5.74E-03
Pb-211	3.4	6,200	430,000	5.41E-04	7.80E-06
Pb-212	1.3	320	430,000	4.16E-03	3.09E-06
Pb-214	14.0	8,200	430,000	1.71E-03	3.26E-05
Po-210	12.6	1.9	350	6.64E+00	3.61E-02
Pa-231	2.3	0.2	55	1.14E+01	4.13E-02
Pa-234	0.0	1,520	430,000	4.77E-06	1.69E-08
Pa-234m	6.4	1,520	430,000	4.24E-03	1.50E-05
Ra-223	3.4	62	3,800	5.41E-02	8.83E-04
Ra-224	1.3	200	9,900	6.65E-03	1.34E-04
Ra-226	14.0	12	55	1.17E+00	2.55E-01
Ra-228	1.5	12	55	1.23E-01	2.68E-02
Th-227	3.4	32	55	1.05E-01	6.10E-02
Th-228	2.7	1	92	2.71E+00	2.94E-02
Th-230	218.3	0.62	89	3.52E+02	2.45E+00
Th-231	0.4	12,000	430,000	3.54E-05	9.87E-07
Th-232	3.1	0.1	18	3.05E+01	1.70E-01
Th-234	6.5	2,800	430,000	2.31E-03	1.50E-05
U-234	6.3	4.2	220	1.49E+00	2.85E-02
U-235/236	0.4	4.2	240	1.01E-01	1.77E-03
U-238	6.5	4.2	240	1.54E+00	2.69E-02
Rn-220	3.0	2	55	1.49E+00	5.42E-02
Rn-222	14.0	10	260,000,000	1.40E+00	5.38E-08
Total (Ci)	370				
Mass (lbs)	7.99E+06				
			Sum of the Fractions	526	4.0

B-3.2 Final Hazard Categorization

The potentially releasable inventory (PRI) is the amount of radioactive or hazardous material that can be released and present a respirable hazard.

B-3.2.1 Material at Risk

The material at risk (MAR) is the inventory of Silo 3 material in each segment. As shown in TABLE B.2.1, the radiological inventory in Silo 3 is 370 Ci, the inventory in the Process Building and Cargo Container Bay is 5.64 Ci. The inventory in the ISA is contained in DOT shipping containers which are analyzed and authorized in the *Test Report for Fernald Environmental Project Silo 3 IP-2 Container Testing* (Doc. No. 0202615-010 MHF).

The MAR for the silo failure during wall cutting will be reduced from the total Silo 3 inventory because some material has been removed from the vicinity of the wall cut before performing the wall cut operation. For analysis purposes it was assumed that 25 percent of the original silo material volume has been removed before the collapse.

B.3.2.2 Potentially Releasable Inventory

The PRI is that portion of the MAR source term released external to the facility. It is a function of the accident, the release fraction or rate, and the facility leak path factor.

Solids Released

The silo failure during wall cutting (EBA-2 in Appendix G) results in the release of solids. The configuration of the remaining silo material is such that the angle of repose from the floor area at the wall opening to the high solids level at the center of the silo is less than 45 degrees. Material release at the time of collapse would result from material falling toward the collapsed region. The material spilling out of the collapsed region would be minimal and it is conservatively assumed that 1 percent of the silo MAR, at the time of collapse, spills outside the silo, into the below ground-level excavator room. The solid mass released is 7.99×10^6 lb x 0.75 x 0.01 = 59,930 lb.

Solids released as a result of the other EBAs are significantly less than those released in EBA-2 (see Appendix G for details). Therefore EBA-2 is the scenario evaluated for hazard categorization purposes.

Radon Released

The initial radon release from the silo failure during wall cutting is conservatively assumed as 0.0356 Ci, which assumes a maximum headspace concentration, where no silo ventilation was in operation. In addition to the initial radon release, radon would be released from the remaining silo material at a rate of 4.7×10^6 pCi/minute over the next 24 hours.

B-3.2.3 Hazard Categorization Based on Radiological Dose Criteria

To demonstrate no significant localized consequences, dose consequences are determined for workers at 30 m, for comparison to the dose threshold criteria of DOE HC-3 facilities (10 rem over a 24-hour exposure).

The methods used to determine the dose consequence or committed effective dose equivalent (CEDE) for each accident scenario use variations of the following general equation [Ref. 16]:

$$CEDE = \sum (MAR * DCF * DR * BR * ARF \text{ or } ARR * LPF * RF * (\chi/Q) * T)_i$$

where:

MAR	=	amount of a radionuclide available to be acted upon by a physical stress (pCi)
DCF	=	dose conversion factor in mrem/pCi
DR	=	damage ratio or the fraction of the MAR actually impacted by accident conditions
BR	=	breathing rate of a reference person considered = 3.33×10^{-4} m^3/sec
ARF	=	airborne release fraction
ARR	=	airborne release rate
LPF	=	leak path factor or the fraction of material transported through some confinement
RF	=	respirable fraction
χ/Q	=	long-term dispersion factor in sec/m^3
T	=	exposure time in hours
i	=	each radionuclide

The dispersion factor (χ/Q) for a straight line, ground level release, is determined from a Gaussian plume model for continuous point source emission in accordance with Nuclear Regulatory Commission's *Regulatory Guide 1.145* [Ref. 17]. A wind speed of 1.0 m/second and D stability class was used at a distance of 30 m, which is consistent with the recommendations of DOE-STD-1027-92 [Ref. 4], for HC-3 criteria. A wind speed of 4.5 m/sec and D stability class was used at 100 m, which is consistent with the recommendations of DOE-STD-1027-92 for HC-2 calculations. The χ/Q is 1.77×10^{-2} at 30 m and 1.05×10^{-3} at 100m.

For a continuous release, the receptor is assumed to be exposed for 24 hrs at 30 m and 2 hrs at 100 m and 330 m. For an instantaneous release, the material is assumed to be completely released within 1 hour. The receptor is exposed during this hour to the instantaneous release, and for the entire exposure period to resuspended solids that are emitted continuously.

All Silo 3 material is in powder form. For EBA-2, dose resulted from powders impacted by falling objects, radon release, and radon flux. The ARF for powders impacted by a falling object (Page 4-85, HDBK-3010), is 1×10^{-3} and the RF is 0.1.

The DCFs were obtained from Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion* [Ref. 18]. The Ra226 DCF, lung clearance class Y, is obtained from CAP88-PC Version 2.1, which was determined using the RADRISK code.

The dose from exposure to radon is determined from the Radon Modeling Report [Ref. 19].

Dose results for hazard categorization purposes are presented in **TABLE B.3-2**.

TABLE B.3-2: RADIOLOGICAL DOSE CONSEQUENCES

Receptor Distance	Solids Results	Radon Results for Initial Release	Radon Results for Flux	Total CEDE (rem)
	Dose (mrem)	Dose (mrem)	Dose (mrem)	
Silo Failure During Wall Cutting (EBA-2 Appendix G)				
30 m (HC-3)	273	18	3	0.3
100 m (HC-2)	16	4	< 1	0.02

The total dose is the sum of the dose from solids, the dose from radon released initially, and the dose from radon released continuously. These results demonstrate no significant localized consequences and therefore support a hazard categorization of Radiological (RAD) for the Silo 3 retrieval and disposition activity.

B-3.3 COMPARISON OF CHEMICAL CONSTITUENTS TO THRESHOLDS

Radiological facilities with inventories of hazardous materials at or above the levels specified in 40 CFR 355, *Emergency Planning and Notification,* shall develop the same safety documentation as required for "non-nuclear" facilities.

Once it is determined that the threshold values have been exceeded, an evaluation of the consequence severity is conducted to properly classify the hazard as high, medium, or low. Non-nuclear facilities are classified as either having high, moderate, or low hazards, based on the following guidelines and those provided in **TABLE B.3.3.**

- High: Hazards with a potential for on-site and off-site impacts to large numbers of persons or for major impacts to the environment
- Moderate: Hazards that present considerable potential on-site impacts to people or the environment, but most only minor off-site impacts
- Low: Hazards which present minor on-site and negligible off-site impacts to people and the environment

The High, Moderate, and Low health consequences may be related to an Emergency Response Planning Guide (ERPG) system [Ref. 20], where the ERPGs are the only well-documented parameters developed to date specifically for use in evaluating the health consequence of the general public to accidental releases of hazardous chemicals. Within the ERPG system, three biological reference values are defined as follows:

- ERPG-1: The maximum concentration in air below which it is believed nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor
- ERPG-2: The maximum concentration in air below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action
- ERPG-3: The maximum concentration in air below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

TABLE B.3-3: CHEMICAL HAZARD CLASSIFICATION GUIDELINES

Hazard	On-Site Concentration	Off-Site Concentration
High	N/A	Greater than ERPG-3
Moderate	Greater than ERPG-3	From ERPG-2 to ERPG-3
Low	From ERPG-2 to ERPG-3	From ERPG-1 to ERPG-2

B-3.3.1 Comparison of Potentially Releasable Hazardous Chemicals to Thresholds Limits

Of the 22 chemicals listed in Section B.2, only five exceed the TPQ values, for the silo failure resulting from an earthquake as shown in Section B.2. The five include arsenic, cadmium, mercury, nickel, and vanadium. For conservatism, these 5 will be considered for analysis. In addition, although not part of the EBA-2 scenario, a ferrous sulfate spill was analyzed independently, since the inventory exceeds the RQ. Results are shown in Table B.3.6.

B-3.3.2 Evaluation of Chemical Consequence Severity and Hazard Categorization

The evaluation guidelines used for determining toxic chemical hazard classification are provided by *Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in DOE Facilities* [Ref. 21]. The consequence severity is determined by evaluating each hazardous chemical in which the PRI exceeds the TPQ.

The peak airborne concentration available to on-site and off-site receptors, is estimated by a straight-line Gaussian dispersion model for each hazardous chemical in which the PRI exceeds the TPQ. The dispersion model uses stability class F and a 1 m/second wind speed. The on-site receptor is assumed to be located downwind at a centerline plume distance of 100 m; while the off-site receptor is located at 350 m (site boundary). Both receptors assume ground level concentrations.

The peak chemical concentrations are then compared to the primary concentration guidelines to determine the appropriate hazard rating (High, Moderate, or Low).

Chemical Dispersion Model

Chemical concentrations were determined using a similar approach to that used for radioactive solids. The peak chemical concentrations (C) for each chemical (i) are determined by the following equation:

$$C_i = \frac{MAR_i \cdot ARF \cdot RF \cdot LPF \cdot DR \cdot \frac{\chi}{Q}}{t}$$

where:

C_i = the concentration (mg/m^3) of the chemical constituent at the receptor

t = the time the release is integrated over

The dispersion parameter (χ/Q) used for chemical dispersion is the same value as used for radiological solids dispersion. A wind speed of 1.0 m/second and F stability class was used. The χ/Q is 9.08 x 10^{-3} at 100m and 9.0 x 10^{-4} at 350 m. TABLE B.3-4 lists the required parameters.

TABLE B.3-4: PARAMETERS FOR CALCULATING CHEMICAL CONCENTRATIONS

Parameter	Initial Release	Ferrous Sulfate Spill
MAR (kg)	Chemical specific	32,000 kg (4,500 gal)
Release duration (t in hrs)	1	1
ARF	1E-3	5E-5
RF	0.1	0.8
LPF	0.01	1
DR	1	1
X/Q @ 100 m	9.08E-3	9.08E-3
X/Q @ 350 m	9.0E-4	9.0E-4

The five chemical compounds are released as a result of the silo failure during wall cutting. The ferrous sulfate spill assumes the 4,500 gal. tank ruptures spilling the entire contents into the Cargo Container Bay. The ARF and RF values are obtained from DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* [Ref. 22], for a free fall spill of a liquid. It is conservatively assumed that the structure provides no containment.

TABLE B.3.5 provides the maximum concentrations of chemical compounds from the postulated scenarios at distances of 100 and 350 m for comparison to the ERPG values for those chemicals.

TABLE B.3-5: CHEMICAL CONCENTRATION COMPARISON TO ERPGS

Chemicals	Concentration		ERPG-1	ERPG-2	ERPG-3
	On-site (mg/m^3)	Off-site (mg/m^3)	(mg/m^3)	(mg/m^3)	(mg/m^3)
Arsenic trioxide	5.61E-02	5.56E-03	0.03	1.4	5
Cadmium oxide	1.96E-03	1.94E-04	0.035	0.05	12.5
Mercuric oxide	9.42E-03	9.34E-04	0.075	0.1	10
Thallium sulfate	1.20E-03	1.19E-04	0.3	2	15
Vanadium pentoxide	9.83E-02	9.75E-03	0.075	0.5	35
Ferrous Sulfate	3.26	0.32	7.5	12.5	350

The on-site concentrations are below ERPG-2 and the off-site concentrations are below ERPG-1. As shown in TABLE B.3.4, these concentrations result in a "Low" chemical hazard classification.

B-4.0 FINAL HAZARD CATEGORY

The results of these analyses demonstrate that the Silo 3 Facility may be reasonably categorized as a Radiological (RAD) Facility with a Low chemical hazard. Anticipated localized dose consequences are not significant, and anticipated chemical concentrations do not exceed the corresponding ERPG concentrations.

These analyses are appropriate for the development of graded safety analysis required by 10 CFR 830 Appendix A, Table 2 [Ref. 8]. Detailed accident analyses are provided in Appendix G of the Silo 3 Nuclear Health and Safety Plan, although not required for RAD facilities, to give a better understanding of the material that can be physically released from the facility and the associated risks to workers, the public, and the environment.

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12. 40 CFR 302, *Designation, Reportable Quantities, and Notification*, Title 40 Code of Federal Regulations, Part 302; DOE; current edition

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18. EPA-5201/1-88-020, Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion,* U.S. Environmental Protection Agency; 1998

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21. WSRC-MS-92-206, Rev. 2, *Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in DOE Facilities,* Westinghouse Savannah River Company; March, 1995

22. DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities,* DOE; December, 1994

Appendix C

APPENDIX C
HUMAN FACTORS EVALUATION

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ACRONYMS

ALARA = As low as reasonably achievable

CAT = Construction acceptance testing

CCTV = Closed circuit television

DOE = U.S. Department of Energy

FCP = Fernald Closure Project

FMPC = Feed Materials Production Center

HFE = Human factors evaluation

HMI = Human machine interface

HVAC = Heating, ventilation, and air conditioning

I/O = Input and output

MRS = Mechanical Retrieval System

MWI = Maintenance work instructions

NHASP = Nuclear Health and Safety Plan

OJT = On-the-job-training

OSHA = Occupational Safety and Health Administration

OU = Operable Unit

PLC = Programmable logic controller

PC = Personal computer

P&ID = Piping and Instrument Diagrams

PPE = Personal protective equipment

PRS = Pneumatic Retrieval System

RWP = Radiological work permit

SSC = Structure, Systems, and Components

STD = Standard

VWMS = Vacuum wand management system

PATH FORWARD

At the beginning of final design for the Silo 3 Project, the design engineers were provided with a Human Factors Engineering Design Checklist and design criteria. Design engineers used the checklist to ensure that constraints and recommendations of human factors engineering were included in their design of components and systems. The checklist and criteria assisted design engineers in designing equipment in accordance with human capabilities and limitations.

This Human Factors Evaluation (HFE) was prepared as an appendix to this Silo 3 N-HASP for the request for DOE approval to perform Silo 3 operations. A complete and final HFE requires a thorough review of the human/machine interfaces of all systems within the Silo 3 Project.

As the construction of the Silo 3 Project progresses, the manufacturers' manuals for major equipment will become available. Silos Project personnel evaluate manuals to provide procedure and training guidance. A System Safety Analyst (SSA) reviews all Technically Operationally Significant (T/OS) procedures. Additional evaluations will be performed following dry-runs, walk-downs, and start-up testing so that procedures can be revised as necessary. Further refinements can be performed as lessons learned arise during actual implementation.

C-1.0 INTRODUCTION

This HFE is an assessment of factors important to the safe operation of the Silo 3 Project. The HFE goal is to address stress, ergonomic, procedural, design, and training issues, with a resulting reduction of risk to workers, the public, and the environment due to operator errors. The adequacy of controls has been evaluated based on specific engineering design details. The HFE focus is on the new facility design and pays particular attention to remote operations. The purpose of this HFE is to demonstrate that human factors are adequately considered for Silo 3 Project operations.

According to DOE-STD-3009-94 [Ref. 1], the primary "... emphasis is on human-machine interfaces required for ensuring safety function of safety structures, systems, and components (SSC's) that are important to safety." There is no human-machine interface with safety-significant SSCs in the Silo 3 retrieval and disposition process. Therefore, the emphasis of this evaluation was shifted to activities that could cause unnecessarily high exposures to hazardous/radioactive materials, but still less than those necessary to cause significant local effects, consistent with the concept of As Low As Reasonably Achievable (ALARA). In addition, emphasis is placed on minimizing physical dangers to personnel (i.e., strains or falls) in the course of performing project activities.

C-1.1 Silo 3 Description

The Fernald Closure Project (FCP) Operable Unit (OU) 4 includes four silos: Silos 1 and 2 (also known as the K-65 Silos), Silo 3, and Silo 4. Silos 1 and 2 contain radium-bearing residues from pitchblende ore processes. Silo 3 contains dry uranium oxide and other metal oxides. Silo 4 is empty and has never been used. Silo 3 was built in 1952 and is a free-standing, pre-stressed concrete, domed silo. It is 80 ft. in diameter and the top is about 36 ft. above ground level. The floor system is constructed of seventeen inches of compacted clay, a 2-in.-thick layer of asphaltic concrete, and an eight-inch layer of gravel topped by 4 in. of concrete. Approximately 5,088 yd^3 of metal oxide material reside in Silo 3. The predominant radionuclide of concern is thorium-230, which is produced from the natural decay of uranium-238.

Silo 3 contains metal oxide material generated from the operation of the former Feed Materials Production Center (FMPC), now known as the FCP. Raffinate streams from the FMPC's solvent extraction process were de-watered using rotary vacuum filters. The filtrate streams were then processed through evaporators, and the evaporator concentrates were further processed using either a spray calciner or a rotary calciner. From plant start-up through the mid-1950s, a spray calciner processed the concentrates. Approximately 35 percent of the Silo 3 material is believed to have come from this process. Because of operational difficulties with the spray calciners, a rotary calciner process was implemented. In this process, the evaporator concentrates were transferred to a drum dryer, and finally, to a rotary calciner. The calciner removed residual liquids and converted the metal nitrates to metal oxides. The resulting fine powdered metal oxides were pneumatically transferred to Silo 3 for storage. Transfer of all materials into Silo 3 continued until 1957.

C-1.2 Human Factors Evaluation

The primary objective of human factors engineering is to improve human performance through enhancements in the work environment and human-machine interface (HMI) [Refs. 2 and 3]. Enhancements to the work environment and HMI reduce human errors and their consequences and lead to the following:

- Increased productivity
- Lower costs
- Better product quality
- Decreased equipment and property damage
- Improved program schedules
- Personal job satisfaction
- Further improvements in the safe operation and maintenance of project facilities

Human factors safety guidance provided in DOE-STD-3009-94, Chapter 13 [Ref. 1] refers to the following:

- Allocation of control functions to personnel versus automatic devices
- Staffing and qualification of operating crews
- Personnel training

- Preparation, validation, and use of written procedures to guide operations
- Surveillance and maintenance
- Design of the human-machine interface to build on strengths and protect against the susceptibility to human error in operating crews

HFEs are performed on project designs, operations, activities, procedures, plans, training programs, and other applicable documents and activities with a graded approach. The extent of the graded approach is determined by the following criteria:

- Requirements of the applicable DOE Orders and implementation guidance documents
- Magnitude of the risk being addressed
- Relative importance of the subject matter to the assurance of safety
- Risk and cost evaluation

C-1.3 Evaluation Methodology

A generalized checklist of human factors requirements and criteria was used to evaluate whether the applicable human factors requirements were being met (see ATTACHMENT 1). This checklist (based upon an HFE performed for the OU4 Hazard Analysis Report) [Ref. 4] was assessed for the Silo 3 Operations Phase (see ATTACHMENT 2).

The checklist was provided to appropriate design engineering personnel for review and completion. These individuals reviewed the project against the checklist, indicating whether the design incorporated each requirement. A comment column was provided to allow for further explanation. The checklist has been completed on the basis of final design information (see ATTACHMENT 1). The checklist may be revised, if necessary, based on information gained during construction, procedure development, acceptance testing, and training.

Following receipt of the manufacturers' manuals, Silos Project personnel evaluate manuals to provide procedure and training guidance. A System Safety Analyst (SSA) reviews all Technically Operationally Significant (T/OS) procedures. Additional evaluations will be performed following dry-runs, walk-downs, and start-up testing so that procedures can be revised as necessary. Further refinements can be performed as lessons learned arise from the actual implementation.

C-2.0 SILO 3 PROJECT DESCRIPTION

Access and retrieval of the Silo 3 material will be accomplished by both pneumatic and mechanical systems [Ref. 5]. Before material retrieval is initiated, radon concentrations in the silo headspace will be reduced to acceptable levels. In preparation for mechanical retrieval, a reinforced concrete framework will be installed on the east silo wall, and a section of the silo wall will be removed.

The Pneumatic Retrieval System (PRS) involves vacuuming material through the existing manways on the Silo 3 dome. Material is removed from the eastern side of the silo to allow for wall-cutting activities. Pneumatic retrieval continues from the manways until it is no longer effective or practicable due to either inaccessibility by the pneumatic wand or a

reduction in material flowability. The PRS then transfers material to the Process Building [Ref. 6].

In addition to pneumatic retrieval, a Mechanical Retrieval System (MRS) is used to access and remove the compacted material. An opening is cut in the silo wall to enable mechanical retrieval. A remotely-controlled mechanical excavator transfers Silo 3 material to a bin located in the Excavator Room. The retrieval bin discharge feeder is variable speed, which controls the flow rate of material from retrieval to packaging. All downstream conveyors are single-speed, and are designed to operate at capacities equal to or greater than the maximum capacity of the retrieval-bin discharge feeder. An inclined conveyor transfers the material to the Process Building. Once the Excavator is in full operation, a water-misting system may be employed for dust suppression and stabilization of the working face of the Silo 3 material [Ref. 6].

The Container Management System allows personnel in the Process Building to perform the following functions:

1. Prepare bags and packaging frames for filling.
2. Dispense Silo 3 material from the Feed Conveyor into bags.
3. Add waste conditioning chemicals.
4. Perform swipe sampling and labeling of bags.
5. Convey filled bags into the Cargo Bay for loading.

Lighting will be provided near each of the closed circuit television (CCTV) cameras. Cameras will be provided at the following locations to support access and retrieval: at the Silo 3 north wall; inside the silo dome; on the ceiling above the retrieval bin; and in the excavator room. In the Silo 3 Area, a 20-in. color monitor is located on top of Silo 3 to be used by the vacuum wand management system (VWMS) operator. A controller will be used by the vacuum wand operator to control pan/tilt and zoom of the Silo 3 cameras. A 20-in. color monitor will be in the observation room to be used by the excavator operator. The Operations Support Trailer has two 20-in. color monitors that can view any of the cameras [Ref. 7].

All equipment used for the Silo 3 Project includes control system hardware and a control approach typical of those used in conventional industrial material handling and packaging operations. The control philosophy is based on a combination of automated functions (where applicable) and actions by local operators. Many of the operations, particularly in the Packaging Area, require continuous operator actions and control input on a local basis.

Operator interface is based primarily on local operation with input via local push buttons and hand switches. A primary hand control station is provided at each of the two Package Loading Stands. Other control stations are provided, as required. These control stations are suitably configured for manipulation by operators who are in a standing position alongside the associated equipment.

All controls and instrumentation are suitable for use in an industrial environment. The devices are conventional, commercially-available items with a proven history of performance.

A programmable logic controller (PLC)-based control system is provided to monitor and control the material handling and packaging equipment. All control logic, sequencing, alarm monitoring, and interlocking are performed in the PLCs[1]. All relay logic, timers [non-heating, ventilation, and air conditioning (HVAC)], and other control devices are contained inside the PLC system. Operator push buttons, hand switches, conveyor controls, motion detectors, solenoid valves, etc., are configured as inputs and outputs (I/Os) to the PLC control system. Emergency stop controls are hard-wired and have PLC inputs to reset process PLC control functions.

The main PLC processor is located in the Operations Support Trailer. A minimal number of PLC remote I/O racks are located in the Packaging Area and other locations as required to simplify wiring to conveyor controls, material position sensors, instruments, etc. One or more basic alpha/numeric display stations are provided at strategic locations in the Process Building to display process parameters such as motor amps, pressures, differential pressures, and alarm indications.

Two redundant personal computer (PC)-based HMI stations are installed in the Operations Support Trailer. These HMI stations serve as central points for monitoring and control of the process and supporting utilities. Monitoring and alarming capabilities are configured for all systems. The necessary control functions to support unattended systems[2] are incorporated in the HMI stations. Support systems such as the HVAC systems and the Breathing Air System are controlled and alarmed from the HMI stations.

C-2.1 Silo 3 Operators

The Silo 3 operators will consist of a staff of approximately 12 operators per shift. Operations will be scheduled 5 days/week, 12 hours/day (i.e., a 12-hour shift). The operators will undergo extensive training before the operation.

C-2.1.1 Pneumatic Retrieval

Operators at the Package Loading Stands have overall control responsibility for regulation of PRS operations. The packaging operators communicate with the main PRS operator, who in turn communicates with the VWMS operators by radio voice communication. The PRS operator coordinates retrieval operations to supply silo material to the Package Loading Stands, and to halt retrieval when necessary.

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[1]Exceptions to this are hard-wired emergency stops.

[2]"Unattended" systems are: Process Vent System, Plant and Instrument Air System, Breathing Air System, and all HVAC systems.

Controls for the PRS are located in the Process Building near the Packaging Area. The VWMS operators manipulate the vacuum wand using hand controls. The wand operator inserts, manipulates, or retracts the wand (as required) to retrieve material at a rate appropriate for packaging operations and to minimize buildup in the Pneumatic Retrieval Collector.

The Pneumatic Retrieval Collector has a high-level switch that triggers an alarm in the Process Building and in the Monitoring Room in T-205. When this level is reached in the collector, the PRS operator either reduces or stops the retrieval rate. PCN2

CCTV cameras are installed in the silo and at the VWMS stations on the silo dome. Associated monitors and camera controls are located in the Process Building. The CCTV system allows the PRS operator to view the silo material and the wand movement and to control material retrieval.

C-2.1.2 Mechanical Retrieval

The Excavator is an electrically-powered remote-operated machine. Operator control and machine status monitoring are by radio-frequency-based remote control and telemetry (an emergency alternative will be "umbilical" hard-wiring). A remote control operator station allows the Excavator to be controlled from an observation room adjacent to the Excavator Room. This operator station is capable of initiating and performing all machine surface travel and silo material removal functions. An excavator emergency stop is also provided.

The silo material is raked, carried, or pushed out of the silo to the Retrieval Bin. The Retrieval Bin Discharge Feeder is speed-controlled to feed the material onto the Inclined Conveyor. Material in the Inclined Conveyor is transported to the Transfer Conveyor, which then deposits the material onto the Feed Conveyor. This conveyor has two outlets, leading to two Package Loading Stands. These conveyors are started manually by the packaging operators. Each conveyor is interlocked with the upstream conveyor(s).

A local indicator panel is provided to communicate Inclined Conveyor operation, packaging equipment activities, and other equipment status to the Excavator operator. The operator is required to access and retrieve material at a rate suitable for the packaging operators and to halt excavation if material starts to build up in the MRS conveyors. CCTV cameras are provided in the silo interior, on the Excavator, and near the Retrieval Bin to allow the Excavator operator to view the silo material and the Excavator operation.

C-2.1.3 Training

Operator training is designed to meet the requirements of DOE Order 5480.20A [Ref. 8] that apply to the operation of nuclear facilities. The Fluor Fernald Project Training and Qualification Program (TQP-067) [Ref. 9] will incorporate the training and qualification requirements for Silo 3 activities. Training specific to startup engineers, supervisors, and other personnel is delineated in TQP-067. Continuing training and operator requalification requirements are also described in TQP-067.

The Silo 3 training program will include training on systems overview, facility operations, and field training. Field training will consist of system walkdowns, on-the-job training (OJT), training evaluation standards, completion of operator qualification cards, and assisting in the Silo 3 Construction Acceptance Test (CAT), where possible. Operators who are not able to participate in the CAT will receive OJT where they work side-by-side with experienced, qualified operators.

The Silo 3 operations and field training courses will provide training on the Silo 3 computer terminal and each of the PC screens. Nomenclature and labels on the screens will be coordinated with training materials and procedures to ensure that ergonomic and human factors engineering are implemented as designed. Operator aids will also be built into the PC screens as appropriate to assist the operators in their timely, reliable performance of safety functions.

C-2.2 Silo 3 Maintenance

Human factors engineering principles have been incorporated into the design of Silo 3 equipment and its maintenance (see ATTACHMENT 1). The Silo 3 final design has been reviewed to examine the provisions for maintenance of Silo 3 equipment. Adequate space for accessing and performing maintenance on each piece of Silo 3 equipment has been verified. In addition, adequate space is available to implement radiation protection practices developed pursuant to the radiological work permit (RWP) program (e.g., containments, step-off pads, and temporary shielding).

Maintenance personnel will be qualified in accordance with their craft Training and Qualification Program Description that includes practical evaluation. Maintenance personnel will receive pre-job and RWP briefings, as required.

The manuals for each piece of Silo 3 equipment requiring maintenance will serve as the starting point for development of Silo 3 maintenance procedures. Maintenance Work Instructions (MWIs) are then prepared and approved. MWIs will be validated and verified by a systematic walk-through with as-built equipment. Maintenance personnel will be briefed for each maintenance task, including equipment specifications, maintenance requirements, maintenance instructions, the need for special tools, and safety precautions. Radiation dose rates and potential radioactive contamination will be considered in preparing the MWI for each task to ensure that the work can be done while wearing the needed personal protective equipment (PPE). Specific requirements for dosimetry, shielding, and stay-time limitations will be provided through the RWP process.

Physical stress factors in the work environment for maintenance personnel are not expected to be unusual. Noise, temperature, and humidity within the Silo 3 Process Building should not cause any discomfort to workers that could affect their ability to perform maintenance work. PPE, such as protective clothing and respirators, will be provided as necessary and as specified by RWPs.

C-2.3 Human Factors Evaluation Results

A systematic and thorough evaluation of the HMI related to the construction, operation, and maintenance of equipment and facilities associated with the Silo 3 Project was performed based on the specific engineering design details available at this time. Each of the following four important elements are incorporated into the design, with the requirements proportional to their importance to safety:

- provisions for communication and operator aids to support timely, reliable performance of safety functions
- layout and design of controls and instrumentation, and provisions for labeling that apply the principles of ergonomics and human engineering
- work environments including physical stress, need for protective clothing and equipment, noise levels, temperature, humidity, distractions, and other factors bearing upon the physical comfort, alertness, and fitness of workers
- staffing considerations (e.g., minimum staffing levels, overtime restrictions, facility status turnover between shifts, procedures, and training)

ATTACHMENT 3 lists the industrial safety and human factors requirements applicable to the Silo 3 Project.

C-3.0 CONCLUSIONS

A preliminary HFE has been performed based on the available design information. As construction is completed and the procedures are ready for issue, the procedures will be re-evaluated. The finalized procedures will be incorporated into the training program and the HMI will be fully evaluated. Additional evaluations will be performed following dry-runs, walk-downs, and start-up testing so that procedures can be revised as necessary. Further refinements can be performed as lessons learned arise during actual implementation.

This HFE demonstrates that the essential elements are, or will be, in place to ensure that the important human factors issues have been addressed for the operation and maintenance of the Silo 3 Project.

By the incorporation of these concepts into the project design, plans, procedures, and training, the potential for human error resulting in adverse safety consequences is minimized.

C-4.0 REFERENCES

1. DOE-STD-3009-94, *Evaluation Guidelines for Accident Analysis and Safety Structures, Systems, and Components,* DOE; Change Notice No. 2; April, 2002

2. *Handbook of Human Factors*, edited by G. Salvendy, John Wiley & Sons, Inc., New York, 1987

3. *Human Factors Design Handbook*, Woodson, Wesley E., Barry Tillman, and Peggy Tillman; McGraw-Hill, Inc., New York; 1992

4. HAR-97-0028, *Hazard Analysis Report for Operable Unit 4 (OU4) Silos;* Appendix D, Human Factors Analysis; Fluor Fernald; May 26, 1998

5. 40430-PL-0002, Rev. 0, *Access and Retrieval Strategy for the Silo 3 Project*, Fluor Fernald

6. 40430-RP-0003, Rev. 0, *Process Description for the Silo 3 Project*, Fluor Fernald

7. 40430-PL-0003, *Process Control Plan for the Silo 3 Project*, Fluor Fernald

8. DOE Order 5480.20A, *Personnel Selection, Qualification, and Training, Requirements for DOE Nuclear Facilities*, DOE; November, 1994

9. TQP-067, *AWR Project Training and Qualification Program,* Fluor Fernald

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ATTACHMENT 1: HUMAN FACTORS EVALUATION CHECKLIST			
SILO 3 OPERATIONAL PHASE (SYSTEMS OPERABILITY TESTING, READINESS ASSESSMENT, RETRIEVAL)			
ITEM	QUESTION	RESPONSE*	COMMENT/GOVERNING DOCUMENT
A. Housekeeping and General Work Environment			
1	Are adequate signs posted near maintenance, cleanup, or staging areas to warn workers of special or unique hazards associated with the areas?	Yes	Project-Specific Health and Safety Plan; additional posting requirements will be identified through routine health and safety inspections
2	Are adequate barriers erected to limit access to maintenance, cleanup, or staging areas?	Yes	Project-Specific Health and Safety Plan; additional barrier requirements will be identified through routine health and safety inspections
3	Are working areas generally clean?	Yes	Project-Specific Health and Safety; routine health and safety inspections
4	Are provisions in place to limit the time a worker spends in an extremely hot or cold area?	Yes	Project-Specific Health and Safety Plan
5	Is noise maintained at a tolerable level?	Yes	Project-Specific Health and Safety Plan; noise surveys conducted in out-of-tolerance cases; site noise limit of 85 dB is enforced
6	Are alarms audible above background noise both inside the control room and in the process area?	Yes	System testing; Contingency Plan and Emergency Response
7	Are normal and emergency lighting sufficient for all area operations?	Yes	Final design documents/reports and drawings; System testing
8	Is there adequate backup power for emergency lighting?	Yes	UPS system; Battery powered emergency lighting

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ATTACHMENT 1: HUMAN FACTORS EVALUATION CHECKLIST			
SILO 3 OPERATIONAL PHASE (SYSTEMS OPERABILITY TESTING, READINESS ASSESSMENT, RETRIEVAL)			
ITEM	**QUESTION**	**RESPONSE***	**COMMENT/GOVERNING DOCUMENT**
9	Is the general environment conducive to safe job performance?	Yes	Operations and Maintenance Safe Work Plans; Project-Specific Health and Safety Plan
B. Accessibility/Availability of Controls and Equipment			
1	Are adequate supplies of protective gear readily available for routine and emergency use?	Yes	Project-Specific Health and Safety Plan
2	Are workers able to perform both routine and emergency tasks safely while wearing protective equipment?	Yes	Project-Specific Health and Safety Plan
3	Is emergency equipment accessible without presenting further hazards to personnel?	Yes	Operations and Maintenance Safe Work Plans; Project-Specific Health and Safety Plan; operator training
4	Is communications equipment adequate and easily accessible?	Yes	Project-Specific Health and Safety Plan; Final design documents/reports
5	Would others quickly know if a worker is incapacitated in a process area?	Yes	Project-Specific Health and Safety Plan; Final design documents/reports; buddy system
6	Are the right tools (including special tools) available and used when needed?	Yes	Operations and Maintenance Safe Work Plans; Final design documents/reports; Maintenance and operating procedures
7	Is the workplace arranged so that workers can maintain a good working posture while performing necessary movements to conduct routine tasks?	Yes	Project-Specific Health and Safety Plan; Final design documents/reports
8	Is access to all controls adequate?	Yes	Final design documents/reports

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ATTACHMENT 1: HUMAN FACTORS EVALUATION CHECKLIST			
SILO 3 OPERATIONAL PHASE (SYSTEMS OPERABILITY TESTING, READINESS ASSESSMENT, RETRIEVAL)			
ITEM	**QUESTION**	**RESPONSE***	**COMMENT/GOVERNING DOCUMENT**
9	Can operators and maintenance workers safely perform all required routine and emergency actions, considering the physical arrangement of equipment (e.g., access to the equipment, or proximity of required tasks to rotating equipment, hot surfaces, or points where hazardous material can be vented or discharged to the atmosphere)?	Yes	Final design documents/reports
10	Are valves that require urgent manual adjustments (e.g., emergency shutdown) easily identifiable and readily accessible?	Yes	Final design documents/reports
C. Labeling			
1	Is all important equipment (e.g., vessels, pipes, valves, instruments, controls) legibly, accurately, and unambiguously labeled?	Yes	Final design documents/reports
2	Does the labeling program include components (e.g., small valves) that are mentioned in the procedures even if they are not assigned an equipment number?	Yes	Labeled per the final design requirements; Final design documents/reports
3	Has responsibility for maintaining and updating labels been assigned?	Yes	Configuration Management
4	Are emergency exit and response signs adequately visible and easily understood?	Yes	Project-Specific Health and Safety Plan; Final design documents/reports; worker training
5	Are signs that warn workers of hazardous materials or conditions adequately visible and easily understood?	Yes	Project-Specific Health and Safety Plan; Final design documents/reports; worker training

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ATTACHMENT 1: HUMAN FACTORS EVALUATION CHECKLIST			
SILO 3 OPERATIONAL PHASE (SYSTEMS OPERABILITY TESTING, READINESS ASSESSMENT, RETRIEVAL)			
ITEM	QUESTION	RESPONSE*	COMMENT/GOVERNING DOCUMENT
D. Feedback/Displays			
1	Is adequate information about normal and upset process conditions clearly displayed in the control room?	Yes	Final design documents/reports
2	Are the controls and displays arranged logically to match operators' expectations?	Yes	Final design documents/reports
3	Are the displays adequately visible from all relevant working positions?	Yes	Final design documents/reports
4	Do separate displays present similar information in a consistent manner?	Yes	Final design documents/reports
5	Are automatic safety features provided when a process upset requires rapid response?	Yes	Final design documents/reports
6	Are automatic safety features provided when a process upset may be difficult to diagnose because of complicated processing of various information?	Yes	Final design documents/reports
7	Are the alarms displayed by priority?	Yes	Final design documents/reports
8	Are critical safety alarms easily distinguishable from control alarms?	Yes	Final design documents/reports; distinctive site alarms; worker training
9	Is an alarm summary permanently on display?	Yes	Final design documents/reports
10	Are nuisance alarms corrected and redundant alarms eliminated as soon as practical to help prevent complacency toward alarms?	Yes	Final design documents/reports

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ATTACHMENT 1: HUMAN FACTORS EVALUATION CHECKLIST			
SILO 3 OPERATIONAL PHASE (SYSTEMS OPERABILITY TESTING, READINESS ASSESSMENT, RETRIEVAL)			
ITEM	QUESTION	RESPONSE*	COMMENT/GOVERNING DOCUMENT
11	Have charts, tables, or graphs been provided (or programmed into the computer) to reduce the need for operators to perform calculations as part of the operation?	Yes	Operating procedures; Final design documents/ reports
12	If operators are required to perform calculations, are critical calculations independently checked?	Yes	Operating procedures; Final design documents/ reports
13	Does the computer check that values entered by operators are within a valid range?	Yes	Operating procedures; Final design documents/ reports
14	Do the displays provide an adequate view of the entire process as well as essential details of individual systems?	Yes	Final design documents/reports
15	Do the displays give adequate feedback for all operational actions?	Yes	Operating procedures; Final design documents/ reports
16	Are instruments, displays, and controls promptly repaired after a malfunction?	Yes	Operating procedures; Final design documents/ reports; Maintenance procedures
17	Do administrative features exist that govern when instruments, displays, or controls are deliberately disabled or bypassed and that govern their return to normal service at the appropriate time?	Yes	Operating procedures; Final design documents/ reports
18	Does a formal mechanism exist for correcting human factors deficiencies identified by the operators (e.g., modifications to the displays, controls, or equipment to better meet operators' needs)?	Yes	Operating procedures; Project Quality Control procedures; daily safety briefings

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ATTACHMENT 1: HUMAN FACTORS EVALUATION CHECKLIST			
SILO 3 OPERATIONAL PHASE (SYSTEMS OPERABILITY TESTING, READINESS ASSESSMENT, RETRIEVAL)			
ITEM	QUESTION	RESPONSE*	COMMENT/GOVERNING DOCUMENT
E. Controls			
1	Is the layout of the consoles logical, consistent, and effective?	Yes	Final design documents/reports
2	Are the controls distinguishable, accessible, and easy to use?	Yes	Final design documents/reports
3	Do all controls meet standard expectations (e.g., color, direction of movement)?	Yes	Final design documents/reports
4	Do the control panel layouts reflect the functional aspects of the process or equipment?	Yes	Final design documents/reports
5	Does the control arrangement logically follow the normal sequence of operation?	Yes	Final design documents/reports
6	Can operators safely intervene in computer-controlled processes?	Yes	Final design documents/reports
7	Can process variables be adequately controlled with the existing processes?	Yes	Final design documents/reports
8	Do operators believe that the control logic and interlocks are adequate?	Yes	Final design documents/reports; Operating procedures; operator training/feedback
9	Does a dedicated emergency shutdown panel exist? If so, is it in an appropriate location?	Yes	Final design documents/reports

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ATTACHMENT 1: HUMAN FACTORS EVALUATION CHECKLIST			
SILO 3 OPERATIONAL PHASE (SYSTEMS OPERABILITY TESTING, READINESS ASSESSMENT, RETRIEVAL)			
ITEM	**QUESTION**	**RESPONSE***	**COMMENT/GOVERNING DOCUMENT**
F. Workload and Stress Factors			
1	Is the control room always occupied (i.e., assigned duties do not require the control room operator to be absent from the control room)?	No	Operating procedures; two operators are assigned to each shift
2	Are the number and frequency of manual adjustments required during normal and emergency operations limited so that operators can make the adjustments without a significant chance of mistakes as a result of overwork or stress?	Yes	Operating procedures; operator training
3	Is the number of manual adjustments during normal operations sufficient to avoid mistakes as a result of boredom?	Yes	Operating procedures; operator training
4	Have the effects of shift duration and rotation been considered in establishing workloads?	Yes	Operating procedures; Labor agreements
5	Is the number of extra hours an operator must work if his or her relief fails to show up sufficiently limited so that worker safety is not adversely affected?	Yes	Operating procedures; Labor agreements
6	Is the number of hours an operator or maintenance worker must work during startup or turnarounds sufficiently limited so that worker safety is not adversely affected?	Yes	Operating procedures; Labor agreements
7	Can additional operators (e.g., from other areas or from off- site) be called in quickly to help during an emergency?	Yes	Contingency Plan and Emergency Response; Labor agreements; Labor utilization planning; operator training

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ATTACHMENT 1: HUMAN FACTORS EVALUATION CHECKLIST			
SILO 3 OPERATIONAL PHASE (SYSTEMS OPERABILITY TESTING, READINESS ASSESSMENT, RETRIEVAL)			
ITEM	QUESTION	RESPONSE*	COMMENT/GOVERNING DOCUMENT
8	Is the staffing level appropriate for all modes of operation (e.g., normal, emergency)?	Yes	Labor agreements; Labor utilization planning; operator training
G. Procedures			
1	Do written procedures exist for all operating phases (i.e., normal operations, temporary operations, emergency shutdown, emergency operation, normal shutdown, and startup following a turnaround or after an emergency shutdown)?	Yes	Comprehensive operating and maintenance procedures
2	Are safe operating limits documented providing consequences of deviating from limits and actions to take when deviations occur?	Yes	Comprehensive operating and maintenance procedures; Operator and maintenance training
3	Are procedures current (i.e., are they revised when changes occur)?	Yes	Document Control Plan
4	Do operators believe that the procedure format and language are easy to follow and understand?	Yes	Operator training; daily safety meetings; feedback
5	Are the procedures accurate (i.e., do they reflect the way in which the work is actually performed)?	Yes	Start-up tests; Operator training; daily safety meetings; feedback; Document Control Plan
6	Is responsibility assigned for updating the procedures, distributing revisions of the procedures, and ensuring that workers are using current revisions of the procedures?	Yes	Document Control Plan
7	Are temporary notes or instructions incorporated into revisions of written operating procedures as soon as practical?	Yes	Document Control Plan

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ATTACHMENT 1: HUMAN FACTORS EVALUATION CHECKLIST			
SILO 3 OPERATIONAL PHASE (SYSTEMS OPERABILITY TESTING, READINESS ASSESSMENT, RETRIEVAL)			
ITEM	**QUESTION**	**RESPONSE***	**COMMENT/GOVERNING DOCUMENT**
8	Do procedures address the personal protective equipment required when performing routine and/or nonroutine tasks?	Yes	Conduct of Operations; Radiological Work Permits
H. Training (Subcontractor)			
1	Are new employees trained in the hazards of the processes?	Yes	Project-Specific Health and Safety Plan; Operations and Maintenance Safe Work Plans; site training; Quality Assurance Program Plan.
2	Do operators and maintenance workers receive adequate training in safely performing their assigned tasks before they are allowed to work without direct supervision?	Yes	Project-Specific Health and Safety Plan; Operations and Maintenance Safe Work Plans; Operations and maintenance training; site training
3	Does operator and maintenance worker training include training in appropriate emergency response?	Yes	Operations and maintenance worker training; site training
4	Do operators practice emergency response while wearing emergency protective equipment?	Yes	Performed by Emergency Response Teams
5	Do operators practice emergency response during extreme environmental conditions (e.g., at night or when it is very cold)?	N/A	Performed by Emergency Response Teams
6	Are periodic emergency drills conducted?	Yes	Contingency Plan and Emergency Response; Operator training
7	Are emergency drills witnessed by observers and critiqued?	Yes	Contingency Plan and Emergency Response

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ATTACHMENT 1: HUMAN FACTORS EVALUATION CHECKLIST			
SILO 3 OPERATIONAL PHASE (SYSTEMS OPERABILITY TESTING, READINESS ASSESSMENT, RETRIEVAL)			
ITEM	QUESTION	RESPONSE*	COMMENT/GOVERNING DOCUMENT
8	Does a periodic refresher training program exist?	Yes	Project-Specific Health and Safety Plans; Operations and Maintenance Safe Work Plans; Operations and maintenance training; site training; daily safety meetings; Quality Assurance Program Plan.
9	Is special or refresher training provided in preparation for an infrequently performed operation?	Yes	Project-Specific Health and Safety Plans; Operations and Maintenance Safe Work Plans; Operations and maintenance training; site training; daily safety meetings; Quality Assurance Program Plan.
10	When changes are made, are workers trained in the new operation, including an explanation of why the change was made and how worker safety can be affected by the change?	Yes	Project-Specific Health and Safety Plans; Operations and Maintenance Safe Work Plans; Operations procedures; Operations training; Quality Assurance Program Plan
11	Are operators and maintenance workers trained to request assistance when they believe they need it so safely perform a task	Yes	Operations and maintenance training; Quality Assurance Program Plan
12	Are operators and maintenance workers trained to report near misses as part of the incident investigation program?	Yes	Operations and maintenance training; Safety Incident Report Program
13	Are operators trained to shut down the process when in doubt about whether it can continue to operate safely?	Yes	Operations training; Quality Assurance Program Plan, stop work authority

* Response options = Yes, No, Not Applicable (N/A)

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ATTACHMENT 2: SILO 3 OPERATIONS/MAINTENANCE TASK LIST AND HUMAN FACTORS HAZARDS MATRIX					
TASK	**LOCATION**	**HAZARDS[1,2]**	**PPE[3]**	**FREQUENCY**	**HUMAN FACTORS FEATURES**
Routine Operations					
Startup	Control Stations, top of dome, excavator room.	Human error impacts on Silo 3 operational safety	None	<Monthly	Remote cameras, alarms, indicators, computer monitors, procedures, training, controls layout, displays, labeling, staffing, work environment (noise, distraction, temperature, etc.)
System Monitoring	Control Stations, top of dome, excavator room.	Human error impacts on Silo 3 operational safety	None	Daily	Remote cameras, alarms, indicators, computer monitors, procedures, training, controls layout, displays, labeling, staffing, work environment (noise, distraction, temperature, etc.)
Shutdown	Control Stations, top of dome, excavator room.	Human error impacts on Silo 3 operational safety	None	<Monthly	Remote cameras, alarms, indicators, computer monitors, procedures, training, controls layout, displays, labeling, staffing, work environment (noise, distraction, temperature, etc.)

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ATTACHMENT 2: SILO 3 OPERATIONS/MAINTENANCE TASK LIST AND HUMAN FACTORS HAZARDS MATRIX					
TASK	**LOCATION**	**HAZARDS[1,2]**	**PPE[3]**	**FREQUENCY**	**HUMAN FACTORS FEATURES**
Emergency Operations					
Manual valve ops, equipment control.	Silo dome, excavator room, Process Building	RA	HH, SS, SG	Not expected	Equipment labeling, alarms, indicators, training, controls layout.
Equipment Maintenance					
Pneumatic Retrieval System	Dome, fabric structure	RA, CA	HH, SS, SG, HP, WG, Anti-Cs	Monthly	Access outdoors, work at heights, adequate space, training.
Mechanical Retrieval System	Excavator room	RA, CA	HH, SS, SG, WG, Anti-Cs	Monthly	Access from floor, adequate space, training.
Packaging/Loading System	Process Building	RA, CA	HH, SS, SG, HP, WG, Anti-Cs	Monthly	Access from floor, adequate space, training.
Process Vent System	Process Building	RA, CA	HH, SS, SG, HP, WG, Anti-Cs	Monthly	Access from floor, adequate space, training.
Plant/Breathing Air System	Process Building	RBA	HH, SS, SG, HP, WG	Monthly	Access from floor, adequate space, training.
Wastewater System	Process Building	RBA	HH, SS, SG, HP, WG	Monthly	Access from floor, adequate space, training.
Waste Additive System	Process Building	RBA	HH, SS, SG, WG, HP	Monthly	Access from floor, adequate space, training.

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ATTACHMENT 2: SILO 3 OPERATIONS/MAINTENANCE TASK LIST AND HUMAN FACTORS HAZARDS MATRIX					
TASK	**LOCATION**	**HAZARDS[1,2]**	**PPE[3]**	**FREQUENCY**	**HUMAN FACTORS FEATURES**
HVAC System	2nd floor platform	RBA	HH, SS, SG, WG, HP	Monthly	Access from floor, adequate space, training.
Electrical Building	Equipment pad platform	RBA	HH, SS, SG, WG, HP	Monthly	Access from floor, adequate space, training.
Repairs					
Miscellaneous	Any equipment location	Same as for equipment	Anti-Cs, RP determined by RWP	Infrequent	Planning on a case-by-case basis
Routine Health Physics					
Surveys	Outside RA	RBA	HH, SS, SG, G, HP	Daily	Site housekeeping
Routine Health Coverage					
Miscellaneous	Any equipment location	Same as for equipment maintenance	Same as for equipment	Same as maintenance activities	Same as for equipment maintenance

[1]Standard industrial hazards not listed
[2]RA = Radiation Area (5 to 100 mrem/hr), HRA = High Radiation Area (>100 mrem/hr), CA = Contamination Area (20 to 2000 dpm/100 cm^2 alpha); RBA = Radiological Buffer Area; ARA = Airborne Radioactivity Area
[3]Abbreviations: HH=hard hat, SS=safety shoes; SG=safety glasses, WG = leather work gloves, G = surgeon gloves, FS=face shield, RP = respiratory protection, HP = hearing protection, Anti-Cs includes coveralls, shoe covers and rubber gloves.

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ATTACHMENT 3: INDUSTRIAL SAFETY AND HUMAN FACTORS REQUIREMENTS

The following industrial safety and human factors concerns are standard for industrial operations. Silo 3 Project personnel from multiple disciplines evaluated Silo 3 activities in terms of these concerns, and used a graded approach to determine the appropriate implementation.

ATTACHMENT 3: SILO 3 PROJECT INDUSTRIAL SAFETY AND HUMAN FACTORS REQUIREMENTS		
ITEM	**REQUIREMENTS**	**IMPLEMENTATION**
Procedures/Safe Work Plans		
1	Written procedures are developed, reviewed by all applicable disciplines including operations and safety, and issued for all operating phases (i.e., normal operations, temporary operations, emergency shutdown, emergency operation, normal shutdown, and startup following a significant change/modification shutdown or after an emergency shutdown).	The procedures were developed, reviewed, and approved per Fluor Fernald site requirements documented in MS-2001.
2	Safe operating limits are determined and documented providing consequences of deviating from limits and actions to take when deviations occur.	Safe operating limits are established. Automatic action is taken by the PLC when parameters start to go outside those limits. In order to change a setpoint, an engineering evaluation, including safety impact, is required.
3	A procedure change control process/system is implemented to ensure that all procedures remain current and accurate (i.e., they reflect the way in which the work is actually performed).	Procedures are maintained per Fluor Fernald site requirements documented in MS-2001.
4	A formal mechanism is implemented for correcting human factors deficiencies identified by the operators (e.g., modifications to controls or equipment to better meet operators' needs).	Design changes are completed per the DCN/RCI process.
5	Procedure format and language is reviewed and revised to ensure that they are easy to follow and understand.	Procedures were drafted by the subject matter expert, and formatted and edited by a technical writer to ensure clarity. Procedure development included walkthroughs with affected personnel.

ATTACHMENT 3: SILO 3 PROJECT INDUSTRIAL SAFETY AND HUMAN FACTORS REQUIREMENTS		
ITEM	**REQUIREMENTS**	**IMPLEMENTATION**
6	A process/system for document control, updating procedures, distributing revisions of procedures, and ensuring that workers are using current revisions of procedures is implemented.	Procedure maintenance is done per site requirements documented in MS-2001. A training program and required reading program have been established.
7	Procedures and/or work permits will prescribe the personal protective equipment (PPE) required when performing routine and/or non-routine tasks.	FCP Work Permits and Radiation Work Permits, which include a PPE sheet, are established for routine activities and developed prior to any new activity.
8	Before initial implementation and any subsequent significant revision of any Technical - Operationally Significant (T/OS) project procedures, they are evaluated by a qualified System Safety Analyst for human factors concerns and modified as necessary to ensure accordance with the requirements of this HFE.	The project uses a multi-disciplined team to review and evaluate procedures. This includes a qualified System Safety Analyst who evaluates for human factors concerns and ensures implementation of human factors requirements.
Training (Employees and Subcontractors)		
1	Training is developed, implemented, and evaluated according to the applicable requirements of DOE Order 5480.20A and implemented in training policies, requirements, and procedures.	The training is developed, implemented, and evaluated per site training requirements.
2	Pre-job briefings, safety meetings, and tool box discussions are conducted in addition to, not in lieu of, the required training.	In addition to training, pre-job briefings, safety meetings, and tool box discussions have been conducted and documented with rosters.
3	To qualify as training, an activity requires a method of evaluation and/or performance demonstration to be successfully completed by the trainee(s).	All training has been conducted per site training requirements.
4	Employees and subcontractors are trained in the hazards of the processes, conditions, and equipment used in the work they are to perform.	All workers have trained per site training requirements. In addition, briefings have been performed addressing project-specific hazards.

ATTACHMENT 3: SILO 3 PROJECT INDUSTRIAL SAFETY AND HUMAN FACTORS REQUIREMENTS		
ITEM	**REQUIREMENTS**	**IMPLEMENTATION**
5	Operators and maintenance workers receive adequate training in safely performing their assigned tasks before they are allowed to work without direct supervision, including requesting assistance when they believe they need it and reporting near misses or accidents.	All workers have trained per site training requirements, which include direct supervision during the qualification process.
6	Operator and maintenance worker training includes training in appropriate emergency response.	The emergency response briefing is conducted during the briefing on the N-HASP.
7	Where applicable, operators practice emergency response while wearing emergency protective equipment.	When drills are scheduled, some operators will wear the prescribed protective clothing.
8	Periodic emergency drills are conducted, witnessed by observers, and critiqued.	The project will plan and conduct periodic emergency drills per site requirements.
9	Special or refresher training is provided in preparation for an infrequently performed operation.	When infrequent operations are performed, dry runs or mock-ups will be conducted, as necessary.
10	When changes are made, workers are trained in the new operation, including an explanation of why the change was made and how worker safety can be affected by the change.	Workers will be trained in procedure changes and new operations. The workers will be trained in the basis of changes and new hazards.
11	Before initial implementation and any subsequent significant revision of the project training units, they are evaluated by a qualified System Safety Analyst for human factors concerns and are modified as necessary to ensure accordance with the requirements of this HFE.	The training is developed, implemented, and evaluated per site training requirements. Training is reviewed by a qualified System Safety Analyst for human factors concerns.
Controls and Equipment		
1	Adequate supplies of personal protective clothing and equipment are readily available for routine and emergency use.	Radiological and hazardous material PPE is staged and readily available.
2	Workers are able to perform both routine and emergency tasks safely while wearing the required protective equipment.	Workers are trained and experienced in wearing PPE and are able to perform tasks in PPE.

ATTACHMENT 3: SILO 3 PROJECT INDUSTRIAL SAFETY AND HUMAN FACTORS REQUIREMENTS		
ITEM	**REQUIREMENTS**	**IMPLEMENTATION**
3	Emergency equipment is accessible without presenting further hazards to personnel.	Emergency equipment is located in areas that are accessible during emergencies.
4	Communications equipment is adequate and easily accessible. For situations where workers are wearing anti-contamination clothing and respirators, and especially where noise levels make clear communication difficult, it is recommended that the information concerning equipment available for communications in high-noise environments and communications while wearing respiratory protective equipment be evaluated for implementation.	A means of communication is available in all work areas. Radio communications will be utilized as necessary.
5	Means or methods are provided so that others can quickly know if a worker is incapacitated in a process/activity area.	The buddy system will be maintained for work activities in areas presenting hazards. When the situation for workers is not ALARA, a combination of radios for communication and cameras will be deployed.
6	The right tools (including special tools) are available and used when needed.	Routine and special tools are staged for all anticipated maintenance activities.
7	The workplace is arranged so that workers can maintain a good working posture while performing necessary movements to conduct routine tasks.	The facility configuration is conducive to minimizing injuries due to uncomfortable body positions.
8	The workplace is arranged so that equipment and workers will not tread on nor interfere with the free movement of air lines.	No temporary air lines will be present on the floor or ground areas.
9	Controls, including such things as manual valves, power sources, and controls on portable equipment, are easily identified, readily accessible, and conform to cultural norms (e.g., right is tight, left is loose; up is on, down is off).	All manual valves, circuit breakers, switches, etc. are accessible and labeled in accordance with standard industrial norms.

ATTACHMENT 3: SILO 3 PROJECT INDUSTRIAL SAFETY AND HUMAN FACTORS REQUIREMENTS		
ITEM	**REQUIREMENTS**	**IMPLEMENTATION**
10	Operators and maintenance workers are able to safely perform all required routine and emergency actions, considering the physical arrangement of equipment (e.g., access to the equipment, or proximity of required tasks to rotating equipment, hot surfaces, sharp corners, or points where hazardous material can be vented or discharged to the atmosphere).	All equipment can be safely accessed. No routine or emergency actions are required in high radiation areas.
11	The layout of the consoles and control panels, whether automated or manual equipment is logical, consistent, and effective.	The control room layout is in accordance with 40430-PL-0003.
12	Controls, whether automated or manual, are distinguishable, accessible, and easy to use.	The controls are in accordance with 40430-PL-0003.
13	Controls meet standard expectations (e.g., color, direction of movement).	The controls are in accordance with 40430-PL-0003.
14	Control panel layouts reflect the functional aspects of the process or equipment and, as applicable, logically follow the normal sequence of operation.	The controls are in accordance with 40430-PL-0003.
15	Where applicable, such as for electrical systems and equipment, a dedicated emergency shutdown panel or equivalent grouped emergency shutdown arrangement is provided and appropriately located for ease of access and use in an emergency response situation.	All work on electrical systems will be conducted per site electrical requirements.
Labeling		
1	Important equipment (e.g., vessels, pipes, valves, instruments, controls) is legibly, accurately, and unambiguously labeled.	The labeling is in accordance with 40430-PL-0003.
2	Equipment labels are maintained and updated, as necessary, and are referenced in the applicable operating and emergency procedures as written.	Operator and management surveillances will identify label deficiencies. Equipment labels are identified in operating and emergency procedures.

ATTACHMENT 3: SILO 3 PROJECT INDUSTRIAL SAFETY AND HUMAN FACTORS REQUIREMENTS		
ITEM	**REQUIREMENTS**	**IMPLEMENTATION**
3	Emergency exit and response signs are adequately visible and easily understood.	Signs are in compliance with OSHA requirements.
4	Signs that warn workers of hazardous materials or conditions are adequately visible and easily understood.	Signs are posted in compliance with OSHA and 10 CFR 835 requirements.
5	Safety features, automatic where feasible, are provided when a process/activity upset requires rapid response or when a process upset may be difficult to diagnose because complicated processing of various information.	Automatic safety features are provided (e.g., automatic shutdown for under- and over-pressure).
6	Charts, tables, or graphs are provided (or programmed into a computer) to reduce the need for operators to perform calculations as part of the operation.	Operator aids are provided to minimize the need to perform calculations. For example, aids are provided for determination of carbon bed inventory.
7	Instruments, equipment, and controls are promptly repaired after a malfunction and are tested as appropriate to ensure normal function is restored before being restored to service.	The established maintenance procedures require malfunctioning items to be repaired and tested.
8	Archive samples are characterized and labeled in accordance with Fluor Fernald requirements.	Archive samples are properly labeled and stored per RCRA requirements.
Housekeeping and General Work Environment		
1	Signs are posted near maintenance, cleanup, or staging areas to warn workers of special or unique hazards associated with the areas.	Signs are posted in compliance with OSHA and 10 CFR 835 requirements.
2	Barriers are erected to limit inappropriate access to controlled areas as well as maintenance, cleanup, or staging areas.	Barriers are posted in compliance with OSHA and 10 CFR 835 requirements.
3	Measures are implemented to ensure that working areas are generally clean, and slip, trip, and fall hazards are minimized.	Routine health and safety inspections, as well as worker training, will ensure the areas are clean and free of debris.
4	Provisions are implemented to limit the time a worker spends in an extremely hot or cold area, with adequate break facilities provided.	Safety and Health oversight, safe work plans, the Health and Safety Plan, and worker training will support stay time limits to prevent heat and cold stress.

ATTACHMENT 3: SILO 3 PROJECT INDUSTRIAL SAFETY AND HUMAN FACTORS REQUIREMENTS		
ITEM	**REQUIREMENTS**	**IMPLEMENTATION**
5	If noise levels exceed Occupational Safety and Health Administration (OSHA) limits (85 dB) or a tolerable level (as determined by the Health and Safety Officer), adequate hearing protection will be provided.	Safety and Health oversight, postings, safe work plans, and worker training will ensure hearing protection is utilized.
6	Alarms are audible above background noise both inside and outside of working areas.	System testing ensures alarms are audible.
7	Normal and emergency lighting are sufficient for all area operations, with special attention given to the conditions inside structures, maintaining at least the following levels: • 5 foot-candles: General site/indoor corridors, hallways and exitways, • 10 foot-candles: General shop, when work is being performed, and • 1 foot-candle: Emergency lighting egress paths.	System testing, Safety and Health inspections, and routine surveillances will identify lighting deficiencies and areas requiring corrective action.
8	Backup power for emergency lighting is provided for outdoor work areas and will be provided for indoor work areas when natural daylight is or can be expected to be unavailable.	Back-up power is provided indoors, and is provided outdoors as necessary.
9	Tripping hazard areas, with special concern inside structures, where air lines, electrical cables, and uneven footing could lead to frequent incidents and near misses, are identified.	No tripping hazard areas are currently present.
10	For potentially high-tripping hazard areas (as applicable): On level, but uneven, ground, spread small gravel on the walking surface for proper footing; no large rocks to cause a stumbling point for limited vision operators. An Occupational Safety and Health specialist is consulted and concurs with the acceptability of the walking surface before work is begun.	Safety and Health oversight is available on all work activities to ensure walking surface hazards are eliminated.

ATTACHMENT 3: SILO 3 PROJECT INDUSTRIAL SAFETY AND HUMAN FACTORS REQUIREMENTS		
ITEM	**REQUIREMENTS**	**IMPLEMENTATION**
11	For potentially high-tripping hazard areas (as applicable): Air lines and electrical cables are protected from inadvertent interference by personnel (i.e., tripping hazard) and by vehicles (i.e., running over or parking on); mats, overhead rails, and highly visible conduits are used.	In the event air lines, hoses, or extension cords are temporarily run on the floor or ground for maintenance activities, precautions are taken to minimize the hazards.
12	For potentially high-tripping hazard areas (as applicable): Spread out equipment and activities to the extent possible to decrease noise intensity levels, to provide adequate, uncluttered work areas, to reduce tripping hazards, and to reduce potential for interfering with air lines.	Work activities will be spread out, as practicable with other priorities, to minimize hazards.
13	For potentially high-tripping hazard areas (as applicable): Include in all work plans awareness of and ways to avoid contact with the over-head power line behind Silo 3 near the fence line.	Caution statements will be included in work plans if the hazard is present. A safe working distance will be maintained from power lines in accordance with OSHA.
Workload and Stress Factors		
1	The number and frequency of manual adjustments required during normal and emergency operations are limited so that operators can make the adjustments without a significant chance of mistakes as a result of overwork or stress.	The controls are in accordance with 40430-PL-0003. The facility operation requires a low frequency of manual adjustments. Operator training minimizes the potential for mistakes.
2	The effects of shift duration and rotation is considered and evaluated before establishing workloads.	The shift duration is limited, crew rotation is utilized, and labor agreements require limited workloads.
3	Staffing levels are appropriate for all modes of operation (e.g., normal, emergency).	Sufficient personnel have been trained and staffed to facilitate all modes of operation.

Appendix D

APPENDIX D
ALARA ANALYSIS

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ACRONYMS

ACL = Administrative control level

ALARA = As low as reasonably achievable

ALI = Annual limit on intake

Anti-C = Anti-contamination clothing

CEDE = Committed effective dose equivalent

CFR = Code of Federal Regulations

CPC = Constituent of primary concern

DAC = Derived air concentration

DOE = U.S. Department of Energy

DRD = Direct reading dosimeter

EDE = Effective dose equivalent

FCP = Fernald Closure Project

FMPC = Feed Materials Production Center

HEPA = High-efficiency particulate air

HVAC = Heating, ventilation, and air conditioning

ICRP = International Commission on Radiological Protection

OU = Operable unit

PPE = Ppersonal protective equipment

PSHPP = Project-specific health physics plan

RAZ = Radiation access zones

RC = Radiological control (dept.)

RPP = Radiological protection program

RWP = Radiological work permit

TEDE = Total effective dose equivalent

TLD = Thermoluminescent dosimeter

TRU = Transuranic

UCL = Upper confidence level

ULPA = Ultra-low penetrating air

WL = Working level

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EXECUTIVE SUMMARY

This appendix reflects the results of extensive analyses to minimize dose while optimizing the design and operation of the Silo 3 facility. The purpose of this analysis is to assure that the Silo 3 Project tasks have been designed and specified in a manner that will keep worker and co-located worker radiation doses ALARA. Silo 3 is a phased project consisting of construction, waste retrieval, and finally decommissioning of the retrieval facilities. This analysis does not address the radiation exposure associated with construction or decommissioning.

Each task where significant radiation exposure is expected has been described and analyzed to determine or estimate the number of workers involved, whether personal protective equipment and clothing is required, the time required to complete the task, the total number of times the task will be performed (frequency) during the Silo 3 Project, and the total person-hours of exposure in areas with radiation dose rates above background. The radiation dose rates in each of these areas will be reflected in Radiation Zone Drawings. The dose rate estimates were made on the basis of the Silo 3 final design. Collective dose estimates were calculated for each task based on the current data, and these estimates were summed for operations, maintenance, and other routine tasks. However, whenever there was uncertainty in estimates, assumptions were made that would conservatively overestimate the radiation doses. Finally, the total collective dose estimate or the collective dose budget for the Silo 3 Project was calculated to be approximately 6.9 person-rem. The results of this ALARA analysis can be summarized as follows:

- The collective operations dose during the entire retrieval and packaging evolution is conservatively estimated to be 6.25 person-rem.

- The collective maintenance dose during the retrieval and packaging evolution is conservatively estimated to be 0.66 person-rem.

Because the estimated total collective dose for the Silo 3 Project exceeds 2 person-rem, the ALARA trigger level used at Fernald, a formal ALARA Committee Review will be required. Furthermore, this analysis shows that expected radiation doses are large enough that engineering and operational controls will be needed to keep radiation doses to workers ALARA.

The scope of this ALARA Analysis is focused on support of the development of the final design. The analysis includes equipment installation and other operations and maintenance functions generated as the design matured. Details of the latest design have been incorporated as much as possible into this ALARA Analysis. Further detail required to clearly define operation and maintenance of equipment is generally contained in vendor's operating and maintenance manuals, which are not yet available. Thus, conservative assumptions about the frequency, duration, and complexity of operations and maintenance have been made and used in this analysis. As the construction proceeds and vendor manuals become available, this ALARA Analysis will be further refined to more

clearly define operations and maintenance functions and/or to further reduce the degree of conservatism in the assumptions.

D-1.0 INTRODUCTION

The As Low As Reasonably Achievable (ALARA) Analysis addresses radiological controls for the operational, and facility shutdown phases of the Silo 3 Project. The purpose of this analysis is to ensure that the Silo 3 Project tasks have been designed and specified in a manner that will keep project workers and collocated worker radiation doses ALARA. Alternatives for dose reduction were assessed and optimum controls were selected.

D-1.1 Scope

The scope of this ALARA Analysis is limited to the Silo 3 Project area within Operable Unit (OU) 4. The radiation protection requirements discussed herein, however, apply to all operations at the Fernald Closure Project (FCP). The scope of existing or expected radiological conditions is also limited to occupational exposures of Silo 3 Project workers and collocated workers to ionizing radiation. Environmental releases of radon and any radiation exposure to the off-site population will be addressed in an ALARA Evaluation [Ref. 1]. This Occupational ALARA Analysis addresses radiation protection measures required for equipment, engineering design, and packaging of Silo 3 Project material.

Each task has been described and analyzed to determine or estimate the number of workers involved, the require personal protection equipment (PPE), the time required to complete the task, and the total number of person-hours of exposure in areas with radiation dose rates above background levels. The radiation dose rates in each of these areas were estimated in the Radiation Zone Drawings and incorporated by reference in this ALARA Analysis. Refinements to the dose rate estimates will be based on the final design information, when available. From these data, collective dose estimates were calculated for each task, and these estimates were summed for operation, maintenance and inspection, and other routine tasks. Finally, the total collective dose estimate or the collective dose budget for the project was calculated.

D-1.2 Background Information

FCP, formerly known as the Feed Materials Production Center (FMPC), processed three basic classes of materials:

- Pitchblende ores as they were mined and shipped to the FMPC
- Uranium ore concentrates that had already been refined to some degree at the mill site
- Uranium process residues generated from FMPC metal production operations.

Uranium-bearing ores, as they are mined, contain not only uranium, but also equilibrium concentrations of uranium progeny (i.e., the isotopes of other elements formed through the sequential radioactive decay chains that begin with ^{235}U and ^{238}U). These progeny, which include radium, are mostly removed either in a preliminary milling process or in the refining process (if the ores are not preprocessed through a mill).

When the FMPC processed uranium ore concentrates that had been preprocessed through a uranium mill, a significant portion of the ^{226}Ra and the gamma-emitting progeny had been removed and were thus termed "cold" feed material. However, some of the thorium progeny of uranium (i.e., ^{230}Th) remained within the uranium concentrates due to the inefficiency of the mill in removing this metal, so even though the materials are termed "cold," they are radioactive.

Following solvent extraction processing for uranium removal, the residual metals and other impurities that were also present in the ore concentrates were subjected to further processing for nitrate recovery and to remove slightly soluble organic compounds present from the solvents used in extraction. After a series of filtration steps, the raffinate stream and the filtrate were fed into a series of evaporators, reducing the volume by 90 percent. The concentrates from the evaporation process were transferred to either a spray calciner or a rotary drum drier, depending on the years of operation, to remove the remaining liquids. A rotary calciner was used to convert the metal nitrates in the concentrates to oxides. The spray calciner operated at a temperature of 510°C (950°F), and the rotary calciner operated at a temperature of 650°C (1200°F) to 820°C (1500°F). After calcining, the finely powdered, dried metal oxides were pneumatically transferred by pipeline to Silo 3. No material, except samples, has been removed from Silo 3 since filling operations ceased in 1957.

D-1.3 Process Description

The Silo 3 remediation process consists of two basic parts: retrieval and packaging. When all of the material is removed from Silo 3, the equipment and structures will be dismantled, decontaminated, and dispositioned. The process flow diagram is shown in **FIGURE D.1-1**. The facility layout is shown in **FIGURE D.1-2**.

Retrieval is accomplished in two ways. The pneumatic retrieval system is contained in a steel beam/metal-sided building adjacent to the silo. The pneumatic wands access the silo material through the silo dome, through existing manways. The mechanical retrieval system is housed in an adjacent robust concrete structure. Some material handling and packaging equipment is shared with the pneumatic retrieval system. The silo itself is enclosed in a fabric structure, which provides protection from the elements to personnel operating the pneumatic retrieval system and some measure of containment should any of the waste material escape from the silo.

First, material will be removed from the top of the silo using a vacuum wand through a man-way in the top of the silo. The entrained material will be transported to a pneumatic retrieval collector. A baghouse in series with a cartridge filter will collect any material remaining airborne, where a filter assembly (consisting of a roughing filter, a high-efficiency particulate air (HEPA) filter, and an ultra-low penetrating air (ULPA) filter) will reduce the amount of particulate material released to the atmosphere. Screw conveyors and rotary feeders will transfer the waste to one of two packaging stations where the waste will be dropped into a lined, soft-sided container. The 96 ft^3 bag is a sturdy, soft-sided container, which meets the transportation requirements for an IP-2 package. The

liner, of polyethylene or similar polymer, will be filled using a "bag-out" procedure to ensure that none of the powdered waste is released to the adjacent work area.

The silo 3 material will be conditioned by the addition of a binding agent for dust control and stabilization. The binding agent is a ferrous sulfate and sodium lignosulfonate solution that will be sprayed into the fill chutes. Each of the two Package Loading Stands is a semiautomated system with loading spouts, loading stands, thumper tables, weighing scales, and motorized roller conveyors for transporting the filled bags away from the station.

When sufficient material has been removed from the silo to expose the inside of the silo wall, a second process will be used to retrieve the remaining waste. An opening will be cut into the exposed wall of the silo to enable the use of a mechanical excavator. The remotely operated excavator will enter the silo and dig into the waste pile. Removed material will be placed in a below-grade bin and moved from there to the packaging stations by four conveyors. Three of the conveyors are screw-type, and one is a pocketed sidewall belt conveyor. This conveyor has a mating belt that covers the material during transfer. The last of the screw-type conveyors is common to the pneumatic retrieval system.

In both cases, i.e., pneumatic and mechanical retrieval, the end product is an IP-2-approved soft-sided container or bulk bag containing a sealed plastic bag full of Silo 3 material. The packages will be surveyed, decontaminated if necessary, and transferred to a cargo container. When a container is full, i.e., approximately 7 of the bags, it will be removed and staged for final shipment to off-site.

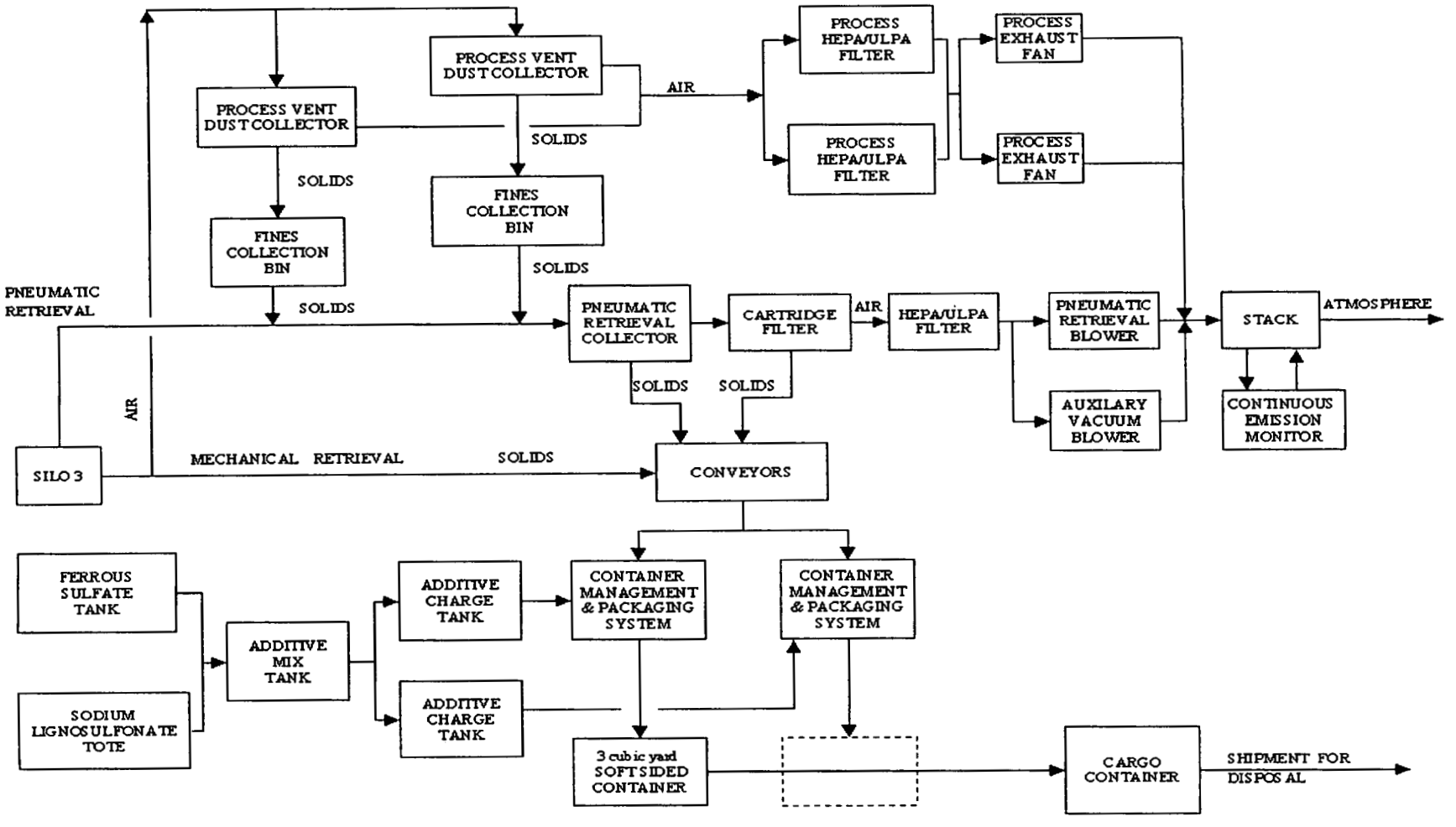

FIGURE D.1-1. SILO 3 PROCESS FLOW DIAGRAM

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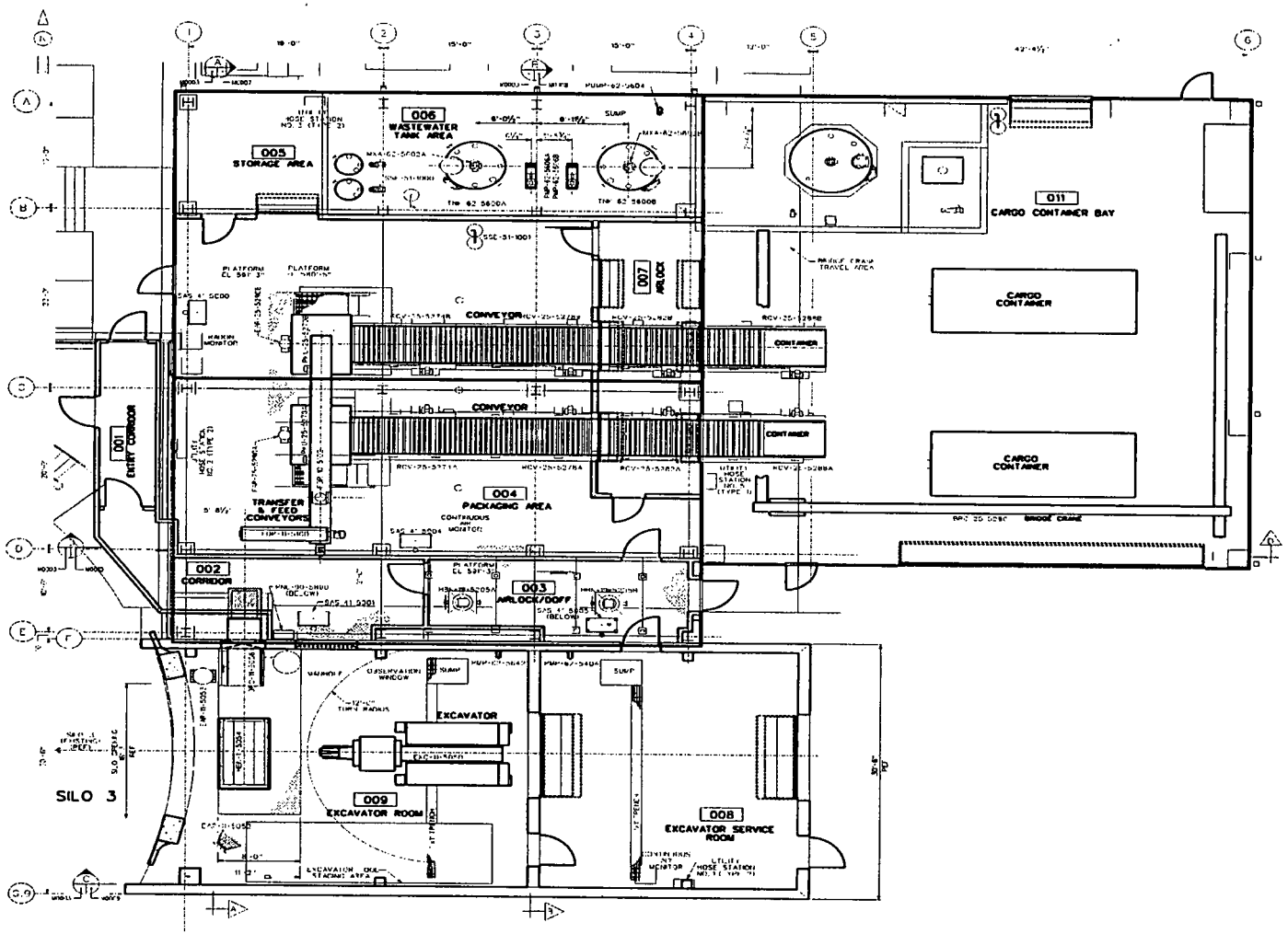

FIGURE D.1-2. SILO 3 PROCESS BUILDING LAYOUT

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D-2.0 GENERAL REQUIREMENTS

The radiological requirements for design ensure that all functions and activities are performed to maintain exposure ALARA. The ALARA philosophy requires any exposure to ionizing radiation by general employees or the public be minimized to the extent that social, technical, economic, practical, and public policy considerations allow. Project management is committed to keeping exposure ALARA through engineering (design), management (administrative controls), and supervision (procedures). This principle is implemented by six key elements:

- Reduce the time spent within radiological areas (i.e., remote excavation and excavator service room)
- Reduce the source(s) of radioactivity (i.e., ventilation filters, exhaust stack)
- Increase the distance from sources of radioactivity (i.e., remote excavation)
- Provide containment of, and shielding from, sources of radioactivity (i.e., enclosed conveyors, retrieval bin hood)
- Minimize internal exposures through the use of confinement and ventilation (i.e., packaging bag-out system)
- Reduce the labor requirements for operations in radiological areas (i.e., vacuum wand management system).

These six key elements are weighed against economic factors, technical feasibility, practicality, public policy, and social needs in implementing the best design.

Management is committed to reducing radiation exposures by applying the ALARA process to design, construction, operation, maintenance, and demobilization of the project. These exposures shall be maintained as far below the DOE occupational exposure limits as social, technical, economic, practical, and public policy considerations permit.

Three approaches are incorporated in the designing, commissioning, operating, maintenance, and decommissioning phases of the Silo 3 Project facility:

- Facility design or modifications and radiation-exposure-causing activities are systematically evaluated with radiological and safety considerations as the highest priorities to keep exposures to individuals and releases to the environment ALARA.
- Personnel are trained in ALARA principles and practices. Additionally, personnel shall adhere to radiological control requirements during operations, maintenance, and support activities to minimize radiation exposures.
- Personnel and facilities at the Silo 3 Project are monitored for radiation hazards. This monitoring is documented to verify that exposures are ALARA.

D-2.1 Design Criteria

ALARA considerations are an integral part of the design process. Qualitative and quantitative analyses are performed on proposed design features to choose an engineered and/or administrative control that will provide a radiological work environment that is ALARA. To capture the ALARA analyses that were performed as part of the design process, a checklist was used for each Silo 3 Project area. The radiation exposure associated with each system and the dose reduction options were considered. **TABLE D.2-1** identifies the features designed to keep exposures ALARA and the associated rationale. **TABLE D.2-2** shows where the Silo 3 ALARA features apply.

TABLE D.2-1: ALARA FEATURES

	SYSTEM	FEATURES
1	Silo enclosure	Protects workers from weather
2	Pneumatic retrieval collector and process vent dust collectors	Removes high concentrations of particulates from air stream
3	HEPA/ULPA filters and prefilters retrieval	Removes particulates from air stream in each ventilation system
4	Pneumatic retrieval blower and auxiliary vacuum blower	Provides for optimum ventilation system performance
5	Building ventilation system	Directs ventilation air from cleaner areas to more contaminated areas, to air treatment systems, and the stack
6	Retrieval bin hood	Reduces airborne concentrations in excavation room
7	Enclosed conveyors	Contains powders during material movement
8	Inclined conveyor double belt	Limits material spillage during lifting of material
9	Gravity flow of material and primary and secondary	Limits equipment and associated containment problems
10	Rotary feeders in-series	Prevents overfilling of bags
11	Excavator service room	Provides for excavator maintenance in cleaner area
12	Polyethylene bag liner	Delays diffusion of radon and provides dust control and containment
13	Local shielding	Reduces dose rates in work areas near large volumes of waste where appropriate
14	Remote excavation	Minimizes personnel exposure to bulk waste
15	Exhaust stack (125 ft high)	Provides for dispersal of trace radon and particulates not collected elsewhere
16	Isokinetic stack monitor	Provides real-time assessment of release rates
17	Retrieval and processing areas	Provides secondary control of contamination
18	Vacuum wand management system	Limits personnel exposure to bulk amounts of waste
19	Packaging bag-out system	Controls contamination during packaging
20	Sumps and wastewater tanks	Collects and holds wash water for disposal
21	Process vent system	Provides venting of equipment to capture airborne material

TABLE D.2-2: SILO 3 APPLICATION OF ALARA FEATURES (Numbers refer to ALARA features listed in TABLE D.2-1)			
Exposure Route	**System**		
	Pneumatic Retrieval	**Mechanical Retrieval**	**Packaging and Container Management**
External	19, 14, 21	15, 14, 21	14, 21
Surface contamination	4, 5, 7, 9, 10, 18, 21	4, 5, 6, 7, 8, 9, 11, 12, 18, 21	9, 10, 18, 20, 21
Airborne contamination	2, 3, 4, 5, 6, 7, 9, 10, 18	3, 4, 5, 6, 7, 8, 9, 11, 12, 18, 21	3, 4, 5, 9, 10, 18, 20, 21
Environmental release (particulate)	2, 3, 16, 17, 18, 21	3, 16, 17, 18, 21	13, 16, 17, 18, 21
Environmental release (radon)	16, 17	16, 17	3, 16, 17
Environmental release (water)		21	

D-2.1.1 External Exposure and Shielding Criteria

The criteria for the Silo 3 Project design will be in accordance with the requirements of 10 CFR 835.1002(c), *Facility Design and Modifications* [Ref. 2]. Specifically, the design objective for controlling personnel exposure from external sources of radiation in areas of continuous occupancy (2,000 hours per year) shall be to maintain dose rates below an average of 0.5 mrem per hour and as far below this limit as is reasonably achievable. Therefore, the continuous occupancy design objective for the gamma radiation exposure rate is established at 0.5 mR/hour. Areas with exposure rates in excess of the 0.4 mR/hour objective are intended to be controlled through administrative and work improvement processes, ensuring personnel exposures are minimized. The Silos 3 Project has adopted a more restrictive dose objective of 0.4 mR/hour to allow for an offset of the expected annual dose from airborne radon. An exposure rate of 0.4 mR/hour is assumed equivalent to a dose rate of 0.4 mrem/hour.

D-2.1.2 Control of Airborne Radioactive Materials

The criteria for new facility design shall be in accordance with the requirements of 10 CFR 835.1002(b), *Facility Design and Modifications* [Ref. 2]. Specifically, the design objective of confinement and ventilation for the control of airborne radioactive material shall be, under normal conditions, to avoid releases to the workplace atmosphere and in any situation, to control the inhalation of such material by workers to levels that are ALARA. Confinement and ventilation shall normally be used.

The design has been reviewed to ensure that concentrations of radioactive materials, especially radon, in occupied areas during normal operating conditions are ALARA. The airborne concentrations are not expected to exceed 10 percent of the derived air concentration (DAC) listed in 10 CFR 835, Appendix A. Therefore, respirators would not

normally be required. However, alpha Continuous Air Monitors will be used to provide an alert and a respiratory protection program will be in place.

Design features have been incorporated to prevent the buildup and spread of contamination. Surfaces from which radioactive material can be resuspended are minimized (e.g., scaffolding, open rafters, hanging light fixtures, cable runs). The ventilation system and facility layout design will ensure that:

- Appropriate pressure differential exists between the areas of high contamination and the outside to prevent the spread of contamination. It is required that the isolation area (work area) have a pressure difference of 0.1 to 0.5 in. water gauge relative to its adjacent area.

- The potentially contaminated airflow is directed away from the worker's breathing zone and is designed to minimize resuspension of contamination. Room air may be recirculated if adequate HEPA filtration and monitoring are provided. Recirculation from an area of higher contamination to an area of lower contamination is prohibited.

- The capture velocity of a hood, hose, or plenum used to capture and redirect suspended contamination is equal to or greater than 150 ft/minute as measured at the source.

- Potentially radioactive particulate effluent discharges are minimized by using HEPA/ULPA filtration. The discharge from ventilation systems is directed away from potential sources of contamination to prevent resuspension.

- The facility layout includes a series of barriers enclosing the various zones that are classified according to the potential level of contamination. The number of barriers depends upon the sources of contamination, the confinement efficiency of each barrier, and the number and types of penetrations. The process equipment provides primary confinement; secondary confinement is provided by the enclosure containment. The ventilation system will be designed to assist the physical barriers within the facility in maintaining zone confinement.

D-2.1.3 Design Development

The Silo 3 Project Radiological Engineering Group reviews and ensures that radiological control requirements are incorporated during the facility design. The normal design process involves the following major steps, each of which requires an appropriate level of radiological review, input, and concurrence:

- functional design criteria,
- preconceptual design,
- conceptual design,
- preliminary design [preliminary hazard analysis report or safety assessment],
- final design [final hazard analysis report or safety assessment],
- documented technical safety requirements, and
- operational readiness assessment or review.

The radiological engineering review focuses on the applicable design criteria contained within DOE Order 420.1, *Facility Safety*, Section 4.1, *Nuclear and Explosives Safety Design Criteria* [Ref. 3] and those listed in this ALARA Analysis.

D-2.2 Radiation Protection

The essential features of the radiological protection program used to protect workers, the environment, and the public from exposure to radiation address the following issues:

- The requirements for radiation protection;
- Description of the design features, programs, and procedures to control radiation sources;
- The radiation protection organization and how the Silo 3 project is integrated with the site-wide programs for maintaining exposures ALARA, training, dosimetry, and record-keeping; and
- Description of how radiological releases are monitored and controlled.

The radiological protection requirements for the Silo 3 Project will be documented in a project-specific health physics plan (PSHPP), Appendix H of the NHASP. The PSHPP will describe the radiological hazards and controls for the operational, shutdown, and demobilization phases of the Silo 3 Project.

D-3.0 EXISTING RADIOLOGICAL CONDITIONS

D-3.1 Silo 3 Material

Silo 3 contains about 5,100 yd^3 of calcined byproduct material from uranium ore concentrate processing. Because of the evaporation and calcinations of this material, the water content is low, ranging between 3.7 and 10.2 percent [Ref. 4]. Initial tests at the FCP have shown that approximately 90 percent of the Silo 3 residues pass through a 200-mesh sieve indicating that the majority of the contents are silt size or less [Ref. 4]. More recent particle size analysis shows that Silo 3 material size distribution includes a significant fraction of the particles are less than 1 micron. The untreated material is easily dispersed. The hygroscopic material exposed to atmospheric humidity will clump and become less easily dispersed.

The specific activities of individual CPCs found in Silo 3 material are shown in **TABLE D.3-1**. The radionuclide inventories are derived from the specific activity results from the sampling of Silo 3 material. These data represent the 95 percent upper confidence limit (95% UCL) on the mean of sample data results. The data used in radiological calculations are based on the 95% UCL on the mean of sample data results. The arithmetic mean values of the sample data are shown for comparison. Shaded rows indicate actual measured concentrations. The remaining radionuclides are decay products assumed to be in secular equilibrium. The length of time for these radionuclides to reach secular equilibrium ranges from 30 to 100 years. Daughter nuclide concentrations vary by only a few percent over this range. In the case where analytical results do not agree with equilibrium calculations, the more conservative values (larger values typically from equilibrium calculations) are used for daughter product concentrations.

TABLE D.3-1 shows that Silo 3 radionuclides consist mainly of alpha emitters and that Th-230 provides over half the total specific activity. More than 80 percent of the relative dose fraction from an uptake of Silo 3 material into the body would result from Th-230. Therefore, survey techniques, contamination controls, and airborne radioactivity controls will be based on those limits set for Th-230.

TABLE D.3-1: SILO 3 MATERIAL-SPECIFIC ACTIVITY[A]				
Radionuclide[b]	Radiation Emitted	Activity Fractions	Arithmetic Mean (pCi/g)	95% Upper Confidence Level of Arithmetic-Mean[c] (pCi/g)
Ac-227	β	0.0079	618	925
Ac-228	β	0.0071		839
Bi-210	β	0.0296		3,480
Bi-211	α	0.0079		925
Bi-212	β	0.0071		838
Bi-214	β	0.0329		3,870
Fr-223	β	0.0001		13
Pa-231	α	0.0053	487	627
Pa-234	β	<0.0001		3
Pa-234m	β	0.0151		1,780
Pb-210	β	0.0296	2,620	3,480
Pb-211	β	0.0079		925
Pb-212	β	0.0071		838
Pb-214	β	0.0329		3,870
Po-210	α	0.0293		3,480
Po-211	α	<0.0001		3
Po-212	α	0.0046		537
Po-214	α	0.0329		3,870
Po-215	α	0.0079		925
Po-216	α	0.0071		838
Po-218	α	0.0329		3,870
Ra-223	α	0.0079		925
Ra-224	α	0.0071	290	838
Ra-226	α	0.0329	2,970	3,870
Ra-228	β	0.0071	297	839
Rn-219	α	0.0079		925
Rn-220	α	0.0071		838
Rn-222	α	0.0329		3,870
Th-227	α	0.0079		925
Th-228	α	0.0071	590	838
Th-230	α	0.5119	51,200	60,200
Th-231	β	0.0010		117
Th-232	α	0.0072	656	842
Th-234	β	0.0151		1,780
Tl-207	β	0.0079		925
Tl-208	β	0.0026		301
U-234	α	0.0147	1,480	1,730
U-235/236	α	0.0010	93.6	117
U-238	α	0.0151	1,500	1,780
Total		1.0000		117,596

[a]Derived from the Remedial Investigation Report for OU4 (November 1993) [Ref. 5]
[b]Radionuclides are assumed to be in secular equilibrium with their parent radionuclides.
[c]Where laboratory analysis disagrees, a conservative decision was made to use daughter product concentrations consistent with equilibrium values.

TABLE D.3-2 is reconstructed from Table 9.9 of the *Technical Basis for Internal Dosimetry at the FEMP* [Ref. 6]; thorium (Th-230) is the most limiting CPC for Silo 3.

TABLE D.3-2: SILO 3 RELATIVE DOSE FRACTIONS

Radionuclide	Assumed Inhalation Class*	Relative Dose Fraction (CEDE)
Uranium	W	0.022
Ac-227	Y	0.062
Pa-231	Y	0.028
Pb-210	D	0.002
Ra-224	W	0.0001
Ra-226	Y	0.007
Ra-228	W	0.0001
Th-228	Y	0.013
Th-230	Y	0.812
Th-232	Y	0.050

*Most restrictive solubility class is assumed unless technical basis exists. D, W, and Y describe the clearance of inhaled radionuclides from the lung. Clearance times are <10 days, from 10 to 100 days, and >100 days respectively for D, W, and Y. For thorium isotopes, Class Y is assumed based on "Technical Basis for Internal Dosimetry at the FEMP" [Ref. 6]. For Ra-226, Class Y is assumed and the dose conversion factor is obtained from CAP88-PC, Version 2.1.

D-3.2 Radon

Within Silo 3, Radon-222 (3.8-day half-life and 5.5-day mean-life) is in secular equilibrium with its radium-226 parent. The nature of radon, being an inert radioactive gas, results in the continual release of the radionuclide from the residues into Silo 3. The actual quantity of radon present within the silo headspace is determined by the production rate (secular equilibrium) and the loss rate. There are essentially two loss mechanisms: the natural decay of the radon gas and the escape of the gas through degraded portions of the concrete silo structure. After a period of time, there is a steady-state quantity of radon within the silo headspace. **TABLE D.3-3** shows the radon inventory details.

Silo 3 retrieval and packaging activities are expected to be impacted somewhat by radon released from the other silos. Workers will receive a small radiation dose from radon diffusing into the atmosphere from Silos 1 and 2, while the total inventory of radon present in the headspace of Silo 3 will be released to the atmosphere under controlled conditions via the exhaust stack. In addition, the radon emission rate may increase slightly during the agitation of Silo 3 material as it is removed from the silo. The radon from Silo 3 will be released via the exhaust stack.

TABLE D.3-3: SILO 3 RADON INVENTORIES AND EMISSIONS		
Parameter	**Silo 3 Storage**	**At Start of Retrieval Operations**
Headspace concentration (pCi/L)	300,000 [a]	212 [e]
Headspace volume (ft^3)	5600 [a]	5600
Headspace activity (Ci)	0.0476 [b]	3.36×10^{-5} [f]
Radon generation rate (pCi/min)	1.78×10^9 [c]	1.78×10^9
Radon transfer rate to headspace (pCi/min)	6.0×10^6 [d]	6.0×10^6
Headspace ventilation rate (ft^3/min)	0	1,000
Emission rate silo leakage (Ci/yr)	2 [h]	-
Emission rate stack exhaust (Ci/yr)	-	6 [g]
Dose at site boundary (330 m) (mrem)	<0.1	<0.1 [g]

a. Design Basis and Requirements Document for the Silo 3 Project [Ref. 4].
b. 300,000 pCi/L x 5,600 ft^3 x 28.32 L/ft^3 = 0.0476 Ci
c. 3,870 pCi/g x 7.99×10^6 lb x 454 g/lb = 14.1 Ci Ra226. 14.1 Ci x 0.693/5500 min = 1.78×10^9
d. A = 0.0476 Ci x 0.693/5500 min = 6.0×10^6 pCi/min (assumes no leakage and to be the same value during retrieval)
e. C = E/Q = 6.0×10^6 pCi/min x 1/1000 ft^3/min x 1/28.3 L/ft^3 = 212 pCi/L
f. 212 pCi/L x 5,600 ft^3 x 28.32 L/ft^3 = 3.36×10^{-5}Ci
g. Stack emission calculation (40430-CA-0003), assuming 35% emanation rate, 100% transfer rate to the headspace. Stack emission rate of 1×10^8 pCi/min for 1000 operating hours.
h. Remedial Investigation Report for Operable Unit 4 [Ref. 5].

D-4.0 ALARA ANALYSIS AND REVIEW PROCESSES

The ALARA Analysis presents estimates of the radiation dose rates, the concentrations of radon in the air, and the duration of exposures. Each Silo 3 Project task was reviewed relative to individual as well as collective doses. Shielding requirements were considered for all the higher dose rate tasks and ventilation requirements were considered for all tasks, where radon concentrations greater than 0.01 WL are expected in the air in occupied spaces. Other factors were considered in the ALARA analyses to determine the duration of exposures, such as the frequency of maintenance tasks, access to equipment that requires maintenance, the path taken to reach the equipment, the complexity and duration of maintenance tasks, local ventilation, and PPE requirements.

For example, consider the preventive maintenance required on a conveyor as a means of describing the methodology of ALARA analyses. The manufacturer's specifications and instructions for the conveyor will give the recommended maintenance frequency, the maintenance procedure, and any special tool or material requirements. The procedure will lead to an estimate of the time, personnel, skills, training, and tools required for a maintenance cycle. Radiological conditions in the vicinity of the conveyor, including dose rates at various distances, decay time, and radon concentrations, will be estimated. Other factors (such as access to the conveyor, stay time limits, temporary shielding, remote tools, PPE, and other) provide the basis for initial individual and collective dose estimates. Consideration will then be given to ways to reduce exposure times, add shielding, improve tools, or other means to reduce the estimated exposures. A collective dose will be calculated for the conveyor maintenance task and all such task, collective doses will be summed for an overall Silo 3 Project collective dose estimate for other waste treatment tasks.

The tasks with the highest collective dose estimates and tasks in the highest dose rate areas will be given the most rigorous technical reviews. Innovative methods and equipment will be incorporated when reasonably achievable to reduce worker exposures to radiation (see TABLE D.2-1).

D-4.1 ALARA Review Criteria

The safety envelope has been defined to include Silo 3 Project operations and maintenance activities that are described in SECTION D-5.4 and tabulated in **TABLE D.5-1**, ALARA Analysis Matrix. The radiological controls necessary for the activities listed in TABLE D.5-1 will be specified in RWPs that will be developed in accordance with RP-0020, *Radiological Work Permitting and Authorization* [Ref. 7]. The RWP system ensures that the ALARA process is used in work planning.

RM-0020, *Radiological Control Requirements* [Ref. 8], establishes occupational ALARA trigger levels intended to provide an intervention point at which the application of occupational ALARA is included in planning and/or evaluating a project. The occupational ALARA trigger levels are:

- Exposure rates >0.5 mrem/hr on average AND an individual is likely to exceed 200 mrem in a year
- Exposure rates >0.5 mrem/hr on average AND the collective dose is likely to exceed 2 person-rem in a year
- An individual is likely to accumulate more than 4 DAC-hours in a week (applying the appropriate respiratory protection factor)
- Entry into areas where dose rates exceed 1 rem/hr
- Reasonable potential for the release of radioactive material (e.g., liquid, airborne) from a system or container to an uncontrolled area in the absence of a release permit or transfer from a controlled or radiological area to an uncontrolled area.

The first two trigger levels will clearly be exceeded in the Silo 3 Project; thus this occupational ALARA analysis is required.

D-4.2 ALARA Committee Review

Each of the routine operation and maintenance tasks in the Silo 3 Project has been evaluated for exposure time, potential dose rate, and estimated collective dose. To accurately estimate exposure times, it was necessary to evaluate each operation, and maintenance task to determine the number of workers necessary, whether they will be wearing PPE, the time required for the task, and the frequency of the task. However, detailed operations and maintenance manuals that would provide these data are not yet available from the manufacturers of each piece of equipment. Therefore, the data provided in this ALARA analysis are based on conservative estimates and general knowledge of comparable operations and equipment. The potential dose rates are conservative estimates based on the shielding calculations, including self-shielding and geometry considerations.

The collective dose estimates in TABLE D.5-1 have been summed to give a projection of the Silo 3 Project total collective dose. An assessment of these projected collective doses gives the relative impact of each task and suggests the level of analysis necessary to ensure that the collective and individual doses are maintained ALARA.

The ALARA Committee, made up of a variety of specialists from operations, maintenance, health physics, industrial hygiene, and industrial safety, critically reviews this analysis. Committee comments are reviewed and responses developed and incorporated to create a well-established starting point for initiation of physical work.

ALARA analysis is a continuous process that is repeated whenever additional data become available that enable refinements in estimates and calculations. As the project proceeds and operations and maintenance manuals are received, specific procedures will be developed that will better define tasks to be conducted in radiological areas. This additional information will be used to refine individual and collective dose estimates and generally reduce the degree of conservatism in the ALARA Analysis.

D-5.0 SILO 3 FACILITY ALARA ANALYSIS RESULTS

This section presents results of the ALARA analyses. Each task of the waste retrieval and packaging that involves significant radiation exposure has been reviewed and analyzed to calculate collective doses with an emphasis on those that pertain to the final design. These analyses are estimates for ALARA purposes.

D-5.1 Duration of Silo 3 Project Tasks

The duration of the Silo 3 Project operation tasks was determined from the Silo 3 current baseline schedule. Construction of the Silo 3 waste retrieval and packaging facility began in the fall of 2002 and operations are scheduled in 2004.

The process for the removal and packaging of Silo 3 waste is subdivided into the following three divisions:

- Pneumatic retrieval of Silo 3 waste by a vacuum wand inserted through a manway in the Silo 3 dome,
- Mechanical retrieval of waste through the side of the silo and material handling of the captured solids to a packaging area where it is placed in bags, and
- Bagged waste is containerized and stored in shipping containers for final transport to an off-site disposal facility.

A plan view of the retrieval/package building first floor, Figure D.1-2, shows the process equipment layout.

D-5.2 Internal Exposure to Radon and Other Radionuclides

Headspace radon and radon generated during mechanical processing of the retrieved, dry waste will be collected in exhaust hoods and ventilated to the atmosphere by the Silo 3 exhaust stack. Calculations of the atmospheric release and dispersion of radon from the exhaust stack show that doses to potential off-site recipients would be negligible [Ref. 9].

Very few project operations will be conducted in airborne radioactive areas where the radon concentrations will exceed 10 percent of the DAC and require respiratory protection. In these cases, the selection and use of respiratory protection equipment will be designed

to prevent internal exposure to radon and its decay products. Fixed radon monitors installed in the Process Building and the Excavator Service Room will be supplemented with portable working level monitors to monitor radon and daughter product concentrations (see Appendix H).

In all cases where workers are exposed to Silo 3 material, they will be required by RWP to wear full PPE and respirators to prevent skin contamination and inhalation of airborne radioactive material. Thus, the probability of project workers being internally contaminated is low. Nevertheless, all project radiological workers will participate in the FCP bioassay program as required.

Radiological Control Technicians will also measure radon concentrations and determine the requirements for respiratory protection for any planning to access areas. The objective of monitoring and respiratory protection is to prevent exposures to radon concentrations in excess of 10 percent of a DAC and to ensure that internal exposures to radon concentrations less than 10 percent of a DAC are maintained ALARA.

D-5.3 Changing Radiological Conditions

The Radon Control System will begin operation in 2003, which will decrease the leakage of radon from Silos 1 and 2. Radon that is not adsorbed by the Radon Control System will be dispersed via the Accelerated Waste Retrieval stack, resulting in a net reduction in the local radon and progeny concentrations.

Before Silo 3 operations conclude in 2004, the transfer of slurry from Silos 1 and 2 to the Tank Transfer Area will begin. Exposed double-wall pipelines carrying the slurry and sluice water will generate some direct radiation exposure. The lines are about 57 feet above grade and greater than 125 feet away from the nearest part of the Silo 3 facility, i.e., the pad containing the heating, ventilation and air conditioning (HVAC) fans, the Pneumatic Retrieval System, the Process Vent System, and the Exhaust Stack. The dose rate at this distance is negligible. Because of the low dose rate, the limited project overlap (in time), and the infrequent occupancy of the ventilation equipment pad this dose contribution was not included in the analysis.

D-5.4 External Radiation Exposure

The individual and collective dose estimates are detailed in this section. The collective dose estimates in TABLE D.5-1 have been summed to give a projection of the total collective dose for major project phases (i.e., operation and maintenance). Assessment of these projected collective doses gives the relative impact of each task and suggests the level of analysis necessary to ensure that the collective and individual doses are maintained ALARA. These estimates will also provide input to the development of project ALARA goals. The dose rate estimates were determined from calculations, existing survey data, and qualitative approximations. During operations, actual doses will be compared to estimated doses to analyze trends and measure performance against ALARA goals. Actual dose data will be used to refine dose estimates and make adjustments where necessary.

The scope of this ALARA Analysis is focused on the retrieval and packaging of the Silo 3 material. Further detail required to clearly define operation and maintenance of equipment is generally contained in vendor's operating and maintenance manuals, which are not yet available. Thus, conservative assumptions about the frequency, duration, and complexity of operations and maintenance have been made by the design engineers and used in this analysis. As vendor manuals become available, this ALARA Analysis will be further refined to more clearly define operations and maintenance functions and/or to further reduce the degree of conservatism in the assumptions.

The number of workers involved in the Silo 3 Project tasks is generally limited to only those workers who actually enter radiological areas to perform work. The "buddy system" of using two workers on a task will be used only when absolutely necessary for safety or efficiency. Supervisors, engineers, trainers, and trainees are not expected to be exposed to the same radiation levels as the primary workers. Furthermore, the estimated exposure times for workers performing radiological work are limited to the actual time spent in radiation areas. It is assumed that workers will perform efficiently and minimize the time spent in these areas because of their skills and training and because the tasks will have been practiced on "cold" systems.

The remainder of this section is focused on external radiation exposures to the Silo 3 Project workers. Radiation doses estimated in this section are taken from Calculation 40430-CA-0016 [Ref. 10], where available, and from Radiation Zone Drawings [Ref. 11]. Radiation exposures to workers will be controlled by means of RWPs, including stay-time limits and local temporary shielding requirements. Actual radiation exposures to workers will be measured by dosimeters, and dosimetry records will be analyzed to ensure that worker exposures are maintained ALARA.

D-5.4.1 Operations

The Silo 3 Project will operate for several months performing material retrieval, treatment, and packaging. The pneumatic retrieval system and the mechanical retrieval system each have a material removal design capacity of 10 yd^3 per hour and a normal operating capacity of 6 yd^3 per hour. Therefore, the entire 5,100 yd^3 material removal could be accomplished in 510 hours at design capacity or 850 hours at normal operating capacity. The exposure durations used in this analysis conservatively assume 1000 operating hours to account for the retrieval operations and routine support activities. This is segmented into 300 operating hours for pneumatic retrieval and 700 operating hours for mechanical retrieval. The schedule duration is assumed to be 6 months, with the understanding that while not operating, the personnel will not always be located in areas with dose rates above background levels. Although a decision may be made by Operations to perform more pneumatic retrieval and less mechanical retrieval, the impact on total collective dose would be small.

The Pneumatic Retrieval System uses a vacuum wand (i.e., vacuum wand management system) to remove the Silo 3 material via five man-ways on the top of the silo dome. This system will operate for approximately 300 hours. Two operators will be on the dome at any given time, at an approximate dose rate of 1.9 mrem/hr, and will rotate out with a

relief crew. The "off-duty" crew will spend the off hours in the Operations Support Trailer (dose rate of 0.1 mrem/hr). A pneumatic retrieval collector will collect and separate the air-entrained waste. The pneumatic retrieval discharge feeder and the primary and secondary rotary feeders will then move the waste material to the Container Management System.

The Mechanical Retrieval System uses a remotely operated mechanical excavator to remove the silo material through an opening in the side of the silo wall. Once sufficient material has been pneumatically removed from behind the wall opening, the silo wall is cut and wall sections are removed to allow excavator access. The 15 ft wide by 20 ft high section is removed in sections with a diamond wire saw. The wall removal operation was estimated to require 4 personnel a duration of 170 hours at an average dose rate of 0.8 mrem/hr. This average dose rate is based on the time durations with the wall in place and with sections removed. Approximately 95 percent of the effort will be performed with the wall in place (i.e., 0.5 mrem/hr). Approximately 5 percent of the effort will be performed with the wall sections removed (5 mrem/hr).

The Mechanical Retrieval System will be operated for approximately 700 hours. Two operators will operate the excavator remotely, observing the operations via a viewing window adjacent to the Excavator Room. The excavator operators will be exposed to a dose rate of 0.4 mrem/hr, which is based on approximately 5 to 6 cubic yards of material in the excavator room at any given time, and at a distance of approximately 15 ft. The calculated dose rate from a bag was used as guidance in estimating the dose rate to these operators. The "off-duty" relief crew will spend off hours in the Operations Support Trailer. A retrieval bin will receive the waste from the excavator and the retrieval bin discharge feeder located beneath the retrieval bin will move the waste material to the inclined conveyor. The inclined conveyor will transport the waste material upwards to a transfer conveyor, which will in turn move the waste to the Container Management System.

The container management system will require 2 packaging room operators to operate conveyors and the packaging equipment. The packaging room operators will be exposed to an average dose rate of 0.4 mrem/hr, assuming an average distance of 7 ft from each bag. In addition, 2 cargo container bay operators will convey the filled bags into the cargo containers via the crane and move containers with a forklift. The cargo container operators will be exposed at approximately 1.8 mrem/hr for 50 percent of the time (based on a distance of 7 ft from a full cargo container) and 0.4 mrem/hr for 50 percent of the time (based on a distance of 18 ft from a full cargo container). One-half hour per bag is assumed based on the throughput rate. Additional operators can be utilized to rotate personnel. In addition, localized shielding could be provided on the forklift to reduce the dose rate to the operator.

Vendors will deliver approximately 270 empty containers, at 0.5 hours per container, in a dose rate of approximately 0.08 mrem/hr. These same containers will be picked up by a driver, at 0.5 hours per container, in a dose rate of approximately 0.1 mrem/hr. Approximately 25 chemical deliveries are estimated, at 1 hour per delivery, in a dose rate of approximately 0.08 mrem/hr.

An RCT will perform routine surveys of the facility and will support work activities. The routine surveys are expected to consist of 2 hours daily in areas at 0.4 mrem/hr, and 2 hours daily in areas at 2 mrem/hr. Operations support activities are estimated to require 2 hours daily in areas at 1 mrem/hr. The remainder of the RCTs time will be in the operations support trailer. The duration of RCT support is 6 months or 132 days.

D-5.4.2 Maintenance and Inspection

The Silo 3 Project process equipment generally consists of specialized waste removal equipment (pneumatic and mechanical), process piping, waste material packaging system, pumps, valves, conveyor systems, process parameter and equipment sensors, air compressors, air filtration systems, miscellaneous electrical switchgear, and fire and radiological monitoring equipment and systems. The frequency and type of maintenance required for this equipment vary, but the maintenance is typically performed monthly and generally consists of the inspection and replacement (as necessary) of seals, impellers, packing, motors, limit switches, bearings, sensors/ transmitters, filters, etc. Maintenance activities also include regularly scheduled equipment testing including limit switches, transmitters, sensors, and alarm setpoints. The durations of the maintenance activities ranged from 1 to 10 hours a month and required 1–2 workers for each maintenance activity. Each equipment item was reviewed to determine maintenance requirements, location of equipment items, and radiation exposure rates at specific maintenance locations. The period of operation was also considered in the descriptions that follow.

The Silo 3 Project is comprised of several major systems: the Pneumatic Retrieval System, the Mechanical Retrieval System, the Container Management System, the Additive System, the Wastewater System, the Process Vent System, the plant/breathing air system, and the HVAC system. Each of these components includes equipment that may require preventative maintenance, and these requirements are considered in the following paragraphs.

Maintenance on the vacuum wand will require two workers in PPE approximately 10 hours a month. The vacuum wand will be pulled off the silo dome for any maintenance. The Pneumatic Retrieval Collector, the discharge feeder, and the rotary feeders will each require two workers approximately 5 hours a month. The exposure rate during maintenance on the vacuum wand system will be 0.1 mrem/hr and for the rest of the equipment will be approximately 0.4 mrem/hr.

Maintenance on the retrieval bin and feeder will each require two personnel in PPE approximately 1 and 2 hours a month, respectively. The exposure rate at each of these pieces of equipment will be approximately 3 mrem/hr. Maintenance on the bottom portion of the inclined conveyor will require 2 personnel in PPE approximately 2.5 hr a month. The dose rate in this area will be approximately 1.0 mrem. Maintenance on the transfer conveyor will require two personnel in PPE approximately 5 hr a month. The exposure rate in this area will be approximately 0.4-2 mrem/hr and average 1 mrem/hr. Maintenance on the mechanical excavator will require two personnel in PPE approximately 10 hours once during mechanical retrieval. The mechanical excavator will be pulled into the Excavator Service Room for maintenance, where the exposure rate will be approximately 1.0

mrem/hr. The rollup doors in the Excavator Service Room will require two personnel in PPE approximately 0.5 hr each door a month.

The Container Management System receives the waste material from either the pneumatic retrieval system or the mechanical retrieval system and packages, weighs, and samples the waste prior to loading the packaged wastes (3 yd^3 bags) into cargo containers. This system is located in the Packaging Area and the Cargo Container Bay. Maintenance on the upper portion of the inclined conveyor and the feed conveyor and associated feed discharge valves requires two personnel in PPE approximately 2.5 hr a month, 5 hr a month, and 1 hr a month, respectively. The exposure rate in this area will be approximately 0.4-2.0 mrem/hr and average 1.0 mrem/hr. Maintenance on each package loading stands will require two personnel approximately 5 hr a month, where the exposure rate is 0.2 mrem/hr. Maintenance on the remainder of the conveyors will each require two personnel approximately 0.5 hr a month, at 0.1 mrem/hr. Maintenance on the bridge crane, forklift, loading crane, will each require two personnel approximately 1 hr a month, at 0.1 mrem/hr. Maintenance of the rollup doors will require 2 workers approximately 2 hours per month, at 0.1 mrem/hr.

The Process Vent System collects and filters air contaminated with radon and metal oxide dust from various process points in the waste retrieval and packaging facility. The air collection registers are located throughout the building to reduce the potential for the spread of contamination in areas where metal oxides are exposed to atmosphere (i.e., mechanical excavation retrieval bin, the excavator room, and the packaging stations). Maintenance on the retrieval bin and excavator room registers will each require one person in PPE approximately 1 hr a month. The exposure rate at these registers will be approximately 3.0 mrem/hr. Maintenance on the process vent dust collectors and the fines collection bins will require two personnel in PPE approximately 1 hr a month and 2 hr a month, respectively. The exposure rate at these pieces of equipment will be approximately 2 mrem/hr. Maintenance on the packaging station registers will require one person in PPE approximately 1 hr a month. The exposure rate at the packaging station registers will be approximately 1.0 mrem/hr. Maintenance on the Process Vent System HEPA prefilters and exhaust fans located south of the Excavator Room will require two personnel approximately 1.5 hrs a month for the prefilters and 2 hr a month for each fan, respectively. The exposure rate at this equipment will be approximately 2.0 mrem/hr at the filters and 0.4 mrem/hr at the fans.

The Wastewater System receives wastewater from the Excavator Room and Excavator Service Room resulting from equipment wash down or excessive misting. The system also receives water from the Additive System sump pump and the Wastewater System sump pump, which is located in the diked area surrounding the Wastewater Tank. Maintenance on the wastewater tank agitator and the wastewater tank pump will each require two personnel approximately 2 hr a month. The exposure rate will be 0.1 mrem/hr. Maintenance on the Wastewater Tank sump pump will require two personnel approximately 1 hr a month, and exposure rate in the area will be 0.1 mrem/hr. Maintenance on the Excavator Room and Excavator Service Room sump pumps requires two personnel in PPE approximately 1 hr a month. The exposure rate for the excavator room will be approximately 3 mrem/hr and for the excavator service room, 0.1 mrem/hr.

The Waste Additive System adds two liquid reagents to the waste material as it is added to the waste bags to reduce fugitive emissions and condition the waste. Reagent totes are delivered and stored in the Cargo Container Bay along with associated metering pumps and a sump pump. The ferrous sulfate tank and pump receive ferrous sulfate from a tanker truck parked outside. The reagents are pumped to an additive tank and additive charge tanks located in the Storage Area. Two metering pumps in this room pump the reagents into the waste material as it is added to the waste bags. Each piece of equipment requires one person approximately 1 hr a month to maintain, and the exposure rate in the area of this equipment is 0.1 mrem/hr.

Air for the HVAC System is supplied via three air conditioning units adjacent to the Wastewater Tank room. Two building filtration exhaust fans are located adjacent to the Excavator Room. In addition, there is a Cargo Container Bay air handling unit, three Cargo Container Bay exhaust fans, and two Wastewater Tank exhaust fans. Two ultra-low penetrating air (ULPA)/HEPA filters are located on the roof of the Excavator Room. General maintenance will require two personnel for each of the units (i.e., 1 hr a month for each of the exhaust fans; 2 hours per month for the air handling unit, and 2 hr a month for each of the air conditioning units). The workers will not require PPE, and the exposure rate in the area will be 0.1 mrem/hr. Maintenance on the ULPA/HEPA exhaust prefilters will require two personnel in PPE 1 hr/month and the exposure rate will be 0.4 mrem/hr.

Electrical switchgear in the Electrical Building provides power to the facility. Maintenance for the electrical switchgear requires two workers without PPE approximately 1 hour a month. The exposure rate in this area will be 0.1 mrem/hr.

Electrical and mechanical equipment used for monitoring and alarming radiological (e.g., radon monitors, continuous air monitors,) and fire parameters will require two workers approximately 4 hours a month. These workers will require PPE approximately 50 percent of the time. Exposure rates will be 0.1 mrem/hr.

TABLE D.5-1: ALARA AND EXPOSURE ANALYSIS MATRIX

Silo 3 Project Operations	No. of Workers (1)	PPE Req'd (2)	Time Duration (hr) (3)	Frequency of Tasks (4)	Person-Hours(5)	Dose Rate(6) (mrem/hr)	Collective Dose(7) (person-rem)	Notes/ Location
FACILITY OPERATIONS								
Pneumatic Retrieval Operations:								
Pneumatic removal wand operator control from top of dome	2	Yes	300	1	600	1.9	1.14	Top of Silo Room 3
Operations support trailer activities	2	No	300	1	600	0.1	0.06	Support trailer
Mechanical Retrieval Operations:								
Perform Wall Cutting Operation	4	Yes	170	1	680	0.8	0.544	Silo 3
Mechanical excavator operations	2	No	700	1	1,400	0.4	0.56	Room 2
Operations support trailer activities	2	No	700	1	1,400	0.1	0.14	Support trailer
Packaging Room Operations								
Bag out, inspection, swipes, installation, weighing, sampling, post-fill swipes, labeling (1885 bags)	2	Yes	0.5	1885	1,885	0.4	0.754	Room 4
Cargo Container Bay Operations								
Position and fill cargo containers and stage and load cargo containers	2	No	0.5	1885	1,885	1.1 average	2.074	Room 7
Truck Drivers								
Transport 270 empty containers	1	No	0.5	270	135	0.08	0.011	East of Room 7

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TABLE D.5-1: ALARA AND EXPOSURE ANALYSIS MATRIX

Silo 3 Project Operations	No. of Workers (1)	PPE Req'd (2)	Time Duration (hr) (3)	Frequency of Tasks (4)	Person-Hours(5)	Dose Rate(6) (mrem/hr)	Collective Dose(7) (person-rem)	Notes/ Location
Pickup 270 full containers	1	No	0.5	270	135	0.1	0.014	
Deliver waste additives (25 deliveries)	1	No	1	25	25	0.08	0.002	East of Room 7
Radcon Technician (6 months or 132 days)								
Health physics surveys	1	No	2	132	264	0.4	0.1056	Room 4
Health physics surveys	1	No	2	132	264	2	0.528	Room 11
Area Surveys operation support	1	No	2	132	264	1	0.264	Various
Operations support trailer activities	1	No	4	132	528	0.1	0.0528	Support trailer
OPERATIONS SUBTOTAL							**6.25**	
MAINTENANCE/INSPECTION								
Pneumatic Retrieval System (2 months)								
Maintain vacuum wand management system	2	Yes	10	2	40	0.1	0.004	
Maintain pneumatic retrieval collector	2	Yes	5	2	20	0.4	0.008	Room 4
Maintain pneumatic retrieval collector discharge feeder	2	No	5	2	20	0.4	0.008	
Maintain primary rotary feeder	2	No	5	2	20	0.4	0.008	
Maintain secondary rotary feeder	2	No	5	2	20	0.4	0.008	

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TABLE D.5-1: ALARA AND EXPOSURE ANALYSIS MATRIX

Silo 3 Project Operations	No. of Workers (1)	PPE Req'd (2)	Time Duration (hr) (3)	Frequency of Tasks (4)	Person-Hours(5)	Dose Rate(6) (mrem/hr)	Collective Dose(7) (person-rem)	Notes/ Location
Mechanical Retrieval System (4 months)								
Maintain retrieval bin	2	Yes	1	4	8	3	0.024	Room 9
Maintain retrieval bin discharge feeder	2	Yes	2	4	16	3	0.048	Room 9
Maintain inclined conveyor	2	Yes	2.5	4	20	1	0.02	Room 9
Maintain/inspect excavator tools	2	Yes	1	4	8	1	0.008	Room 9
Maintain transfer conveyor	2	Yes	5	4	40	1	0.04	Room 4
Maintain excavator	2	Yes	10	1	20	1	0.02	Room 8
Maintain excavator service room rollup doors (2)	2	Yes	1	4	8	1	0.008	Room 8
Packaging/Loading System (6 months)								
Maintain inclined conveyor	2	Yes	2.5	6	30	1	0.03	Room 4
Maintain feed conveyor	2	Yes	5	6	60	1	0.06	Room 4
Maintain feed conveyor discharge valves	2	Yes	1	6	12	1	0.012	Room 4
Maintain loading stands (2)	2	No	10	6	120	0.2	0.024	Room 4
Maintain intermediate packaging conveyors (2)	2	No	1	6	12	0.1	0.0012	Room 4
Maintain packaging staging conveyors (2)	2	No	1	6	12	0.1	0.0012	Room 4
Maintain airlock conveyors (2)	2	No	1	6	12	0.1	0.0012	
Maintain off-loading conveyors (2)	2	No	1	6	12	0.1	0.0012	Room 7

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TABLE D.5-1: ALARA AND EXPOSURE ANALYSIS MATRIX

Silo 3 Project Operations	No. of Workers (1)	PPE Req'd (2)	Time Duration (hr) (3)	Frequency of Tasks (4)	Person-Hours(5)	Dose Rate(6) (mrem/hr)	Collective Dose(7) (person-rem)	Notes/ Location
Maintain bridge crane	2	No	1	6	12	0.1	0.0012	Room 11
Maintain heavy-duty forklift	2	No	1	6	12	0.1	0.0012	Room 11
Maintain loading crane	2	No	1	6	12	0.1	0.0012	Room 11
Maintain airlock rollup doors (4)	2	No	2	6	24	0.1	0.0024	Room 7
Process Vent System (PVS)								
Maintain retrieval bin register	1	Yes	1	6	6	3	0.018	Silo opening
Maintain excavator room register	1	Yes	1	6	6	3	0.018	Room 8
Maintain process vent dust collectors (2)	2	No	2	6	24	2	0.048	Room 4
Maintain fines collection bins (2)	2	No	4	6	48	2	0.096	Room 4
Maintain packaging station exhaust registers (2)	1	No	1	6	6	1	0.006	Room 4
Maintain PVS HEPA filters (2)	2	Yes	1.5	6	18	2	0.036	Adjacent to Room 9
Maintain PVS exhaust fans (2)	2	No	4	6	48	0.4	0.0192	Adjacent to Room 9
Wastewater System								
Maintain wastewater tank agitator	2	No	2	6	24	0.1	0.0024	Room 6
Maintain wastewater pump	2	Yes	2	6	24	0.1	0.0024	Room 6
Maintain wastewater tank area sump pump	2	Yes	1	6	12	0.1	0.0012	Room 6
Maintain excavator room sump pump	2	Yes	1	6	12	3	0.036	Room 9

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TABLE D.5-1: ALARA AND EXPOSURE ANALYSIS MATRIX

Silo 3 Project Operations	No. of Workers (1)	PPE Req'd (2)	Time Duration (hr) (3)	Frequency of Tasks (4)	Person-Hours(5)	Dose Rate(6) (mrem/hr)	Collective Dose(7) (person-rem)	Notes/ Location
Maintain excavator service room sump pump	2	Yes	1	6	12	0.1	0.0012	Room 8
Waste Additive System								
Maintain Waste additive metering pumps	1	No	2	6	12	0.1	0.0012	Room 11
Maintain waste additive sump pump	1	No	1	6	6	0.1	0.0006	Room11
Maintain wastewater additive tank	1	No	1	6	6	0.1	0.0006	Room 5
Maintain waste additive change tanks	1	No	2	6	12	0.1	0.0012	Room 5
Maintain waste additive change tank metering pumps	1	No	2	6	12	0.1	0.0012	Room 5
HVAC System								
Maintain cargo container bay exhaust fans	2	No	3	6	36	0.1	0.0036	Cargo bay roof
Maintain cargo container bay air handling unit	2	No	2	6	24	0.1	0.0024	Adjacent to cargo bay
Maintain packaged air circulation units	2	No	6	6	72	0.1	0.0072	Adjacent to Room 8
Maintain building filtration exhaust fans	2	No	2	6	24	0.1	0.0024	Room 8 roof
Wastewater tank area exhaust fan	2	No	2	6	24	0.1	0.0024	Room 6
Maintain ULPA/HEPA exhaust filters	2	Yes	1	6	12	0.4	0.0048	Room 8 roof

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TABLE D.5-1: ALARA AND EXPOSURE ANALYSIS MATRIX

Silo 3 Project Operations	No. of Workers (1)	PPE Req'd (2)	Time Duration (hr) (3)	Frequency of Tasks (4)	Person-Hours(5)	Dose Rate(6) (mrem/hr)	Collective Dose(7) (person-rem)	Notes/ Location
Electrical Building								
Maintain miscellaneous electrical switchgear	2	No	1	6	12	0.1	0.0012	
Radiological/Fire Monitoring Equipment								
Maintain miscellaneous fire protection and radiological protection equipment	2	Yes	4	6	48	0.1	0.0048	
M/I SUBTOTAL							**0.66**	
OVERALL TOTAL							**6.9**	

Notes:
(1) No. of Workers = number of workers that will actually receive radiation exposure during the task
(2 PPE Required = personal protective equipment required, typically two pairs of coveralls, shoe covers, gloves, hood, and respirator
(3) Time Duration = the actual exposure time in the radiation field
(4) Frequency = the number of times the task must be performed during the entire duration of the Silo 3 Project
(5) Person-Hours = the collective exposure time in the radiation field
(6) Dose Rate = the estimated whole body dose rate (mrem/hr) at the location where the task is to be performed
(7) Collective Dose = the product of Person-Hours and Dose Rate in units of person-rem
(8) Based on expected average dose rate where PPE will be doffed
(9) Based on expected average dose rate where PPE will be doffed

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D-6.0 REFERENCES

1. 40000-RAD-0001, Rev. 1, *Operable Unit 4 (OU4) Silos Project ALARA Evaluation*, Fluor Daniel Fernald, March 28, 1998

2. 10 CFR 835, Section 835.1002 (c), *Occupational Radiation Protection, Facility Design and Modifications*, Title 10 Code of Federal Regulations Part 835; DOE; November, 1998

3. DOE Order 420.1, *Facility Safety*, Section 4.1, *Nuclear and Explosives Safety Design Criteria*, U.S. Department of Energy; Change 2: October 24, 1996

4. 40430-DC-001, *Design Basis and Requirements Document for the Silo 3 Project*, Fluor Fernald; February, 2002

5. FEMP-04RI-6, *Remedial Investigation Report for Operable Unit 4, Final, Volume 1 of 3*, Fernald Environmental Management Project; November, 1993

6. SD-2008, *Technical Basis for Internal Dosimetry at the FEMP*, Fluor Daniel Fernald; April, 1997

7. RP-0020, *Radiation Work Permitting and Authorization,* Fluor Fernald

8. RM-0020, Rev. 1, *Radiological Control Requirements Manual,* Fluor Fernald; June, 2003

9. 40430-CA-019, *Radioactive Particulate and Radon-222 Stack Release Considerations for the Silo 3 Remedial Action Project*, Jacobs Engineering Group; December, 2002

10. 40430-CA-0016, *Silo 3 Area Dose Rate Calculation*, Jacobs Engineering Group; August, 2003

11. 94X-3900-M-05216, M-011 through M-016, *Silo 3 Radiation Zone Drawings,* Jacobs Engineering Group; December, 2002

APPENDIX E
ENVIRONMENTAL ALARA REPORT

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ACRONYMS

ALARA = As low as reasonably achievable

ARAR = Applicable, relevant and appropriate requirements

AWWT = Advanced Wastewater Treatment

DOE = U.S. Department of Energy

FCP = Fernald Closure Project

HEPA = High-efficiency particulate air

HVAC = Heating, ventilating and air conditioning

N/A = Not applicable

NEPA = National Environmental Policy Act of 1969

PEAPR = Project evaluation for air/water permit/notification request

PHAR = Preliminary Hazard Analysis Report

PPE = Personal protective equipment

RCS = Radon Control System

RCT = Radiological Control Technician

RM = Requirements Manual

TBD = To be determined

E-1.0 INTRODUCTION

The as low as reasonably achievable (ALARA) philosophy adopted by the Fernald Closure Project (FCP) requires that any exposure to ionizing radiation to general employees, the public, or the environment shall be minimized to the extent that social, technical, economic, practical, and public policy considerations allow.

An Environmental ALARA Review and Evaluation for Silo 3 was conducted by Jacobs Engineering Group, Inc. (the Engineer of Record). This evaluation covers Silo 3, the bridge for the vacuum retrieval component, the side access port for mechanical retrieval, the facility for treatment and packaging, and the project stack. The information in this appendix is from that evaluation. It has been reformatted and edited for readability. The original signed evaluation forms are on file with FCP Environmental Compliance as Environmental ALARA Log Number 03-003.

E-2.0 ENVIRONMENTAL ALARA EVALUATION DATA-GATHERING

E-2.1 Description Of Activity

Q1: *What is the objective and scope of the issue to be analyzed?*

A1: The objective and scope of the Silo 3 Project includes:

- constructing and operating a structure on top of Silo 3 to hold and manipulate an arm within the silo guiding a vacuum retrieval component.
- creating an access port through the side of the silo to accommodate equipment for physical retrieval of silo material.
- constructing and operating a treatment facility connected to Silo 3 to receive, treat, and package treated Silo 3 material.
- packaging silo material in 3-cubic yard soft-sided packages.
- storing packaged waste near the treatment facility for subsequent transport to a representative permitted commercial disposal facility or Nevada Test Site for final disposition.

All project activities will be conducted in accordance with the Environmental Control Plan for Silo 3 (Document 40430-PL-0005).

Q2: *Does the activity have the potential for a routine or non-routine release of radionuclides (e.g., stack emissions, spills, etc.; include potential releases during construction)?*

A2: Yes, the activities involved in constructing and operating the Silo 3 material retrieval/waste treatment and storage systems have the potential for both routine and non-routine releases of radiological material. Accidental spills have a potential to

occur from the process equipment. Liquids will be added to the dry waste for stabilization. Water will also be used during silo wall cutting and during excavator decontamination.

Q3: *Where is the material released or to be released for a future activity (e.g., air, water, soil, waste)?*

A3: Material will be released indoors and into the environment. Potential airborne and liquid releases indoors may occur from tanks, piping, or sampling activities in the future treatment facility. Airborne releases to the environment could occur from the system stack or other conduits associated with this system. Any controlled liquid releases will be transferred to the Advanced Wastewater Treatment (AWWT) System. Potential liquid releases to the on-site environment may occur from accidents within treatment/storage facility.

Q4: *What radionuclides will potentially be released?*

A4: Primary potential releases from the Silo 3 waste material will include Rn-222 and Rn-220, Ac-227, Ac-228, Bi-210, Bi-211, Bi-212, Bi-214, Fr-223, Pa-231, Pa-234, Pa-234m, Pb-210, Pb-211, Pb-212, Pb-214, Po-210, Po-211, Po-212, Po-214, Po-215, Po-216, Po-218, Ra-223, Ra-224, Ra-226, Ra-228, Rbn-219, Th-227, Th-228, Th-230, Th-3231, Th-232, Th-234, Ti-207, Ti-208, U-234, U-235/236, and U-238.

The material source/origin is calcined raffinate obtained from the extraction of uranium ore. The primary release is particulates, and to a lesser extent, gaseous radon isotopes. There is also the potential release of liquids with some solid particulate material. Drum and container markings will be in accordance with procedural and regulatory requirements.

Q5: *What amount is anticipated to be released (lbs., gallons, curies, etc.) and the source?*

A5: To air: < 0.1 Ci/year particulate, < 10 Ci/year radon-222. Refer to 40430-CA-0003, Rev. 2, *Radioactive Particulate and Radon-222 Stack Release Considerations for the Silo 3 Remedial Action Project* [Ref. 1]

To water: None planned. Water will be used to add fixative to the final waste form.

To Soil: None.

To Waste: Primary waste is 3646 tons of Silo 3 material. Secondary waste consists of filters, and personal protective equipment (PPE) [Ref. 2]

To controlled and/or free release of material: Materials and equipment released will meet 10 CFR 835, Appendix D (or new ANSI N13,12) release standards [Ref. 3].

Q6: *How was the amount determined (estimated, weighed, or otherwise measured)?*

A6: The amount was estimated on the basis of Silo 3 retrieval/treatment/storage performance calculations in 40430-CA-0003 [Ref. 1].

Q7: *Will there be an off-site release (storm water, air release, other)?*

A7: Primarily, there will be controlled airborne release of radionuclides via the Silo 3 Project stack and permitted discharges from the AWWT.

Q8: *Is a hazardous/mixed waste involved? List any special factors as a result.*

A8: No mixed wastes are involved in Silo 3 retrieval/treatment/storage project. The waste is 11(e)(2) byproduct material. The material contains RCRA toxic metals (arsenic, cadmium, chromium, selenium) which exceed TCLP limits. Due to the 11(e)(2) byproduct exemption, it is not regulated as RCRA hazardous waste, but must meet applicable or relevant and appropriate requirements. Approximately 4,500 gal of ferrous sulfate solution will be used for material treatment.

E-2.2 Control of Radioactive Material Releases

Q1: *Describe or reference any protection options considered. Describe air emissions and water discharge control equipment, fugitive dust suppression, material lockdown, handling of waste, secondary containment, spill control equipment, controls on release of material, clean-up of spill material, administrative controls, etc.*

A1: The Silo 3 Project will use the best available technology. The air emissions will be pre-filtered and HEPA-filtered before discharge from the project stack. The effluent from the stack will be monitored in real time for radon concentrations. In addition, the stack will be sampled and monitored for particulate airborne releases. The waste water will be sampled, analyzed, and treated as necessary to meet the AWWT waste acceptance criteria (WAC) before discharge to the AWWT. Any spills will be cleaned up to meet FCP radiological control requirements.

Q2: *How will waste be packaged/labeled/stored (location)/handled? What procedures will be used?*

A2: Material will be treated and packaged for off-site dispositioning at an off-site disposal facility. Applicable FCP procedures (or equivalent Jacobs Engineering Group Procedures) will be used to package, label, store, and handle Silo 3 Project wastes.

Q3: *Release of materials and equipment - surface contamination levels. Prior to being released, will property be surveyed to determine whether both removable and total surface contamination (including contamination present on and under any coating) are*

in compliance with the levels given in Figure IV-1 in DOE Order 5400.5 [Ref. 4] *and that the contamination has been subjected to the ALARA process? Describe or reference documentation of the ALARA process.*

A3: Before release from the controlled area, all material and equipment will be surveyed by FCP Radiological Control Technicians (RCTs) per FCP site radiological control procedures to ensure compliance with requirements set forth in Figure IV-1 of DOE Order 5400.5 release criteria and/or corresponding 10 CFR 835 specifications. The ALARA Process is further discussed in the Silo 3 ALARA Analysis in Appendix D of this N-HASP.

E-3.0 ENVIRONMENTAL ALARA EVALUATION

Q1: *Estimated performance of the control options. How much material will be controlled/removed (%, pounds, etc.)? Identify advantages/disadvantages of each factor and control option. (Note: Use quantitative and qualitative methods when each is appropriate.)*

A1: The ULPA/HEPA filter will remove more than 99.97% of particulates with aerodynamic mean diameter greater than 0.3 micrometers from the stack effluent.

Q2: *Identify cost information for control options (as relevant to the decision).*

A2: The cost impact is considered in the definition of Best Available Technology control. See E3.0 A1.

Q3: *Applicable dose limits and Derived Concentration Guides (DCGs) from DOE Order 5400.5* [Ref. 4]. *Dose impacts, if determined (e.g., dose to the maximally exposed individual, population dose, etc.). Are dose limits or DCGs exceeded?*

A3: No dose limits or DCGs are exceeded. Refer to Silo 3 performance calculations in 40430-CA-0003 [Ref. 1].

Q4: *Analytical Solution. Present the results of quantitative analysis, if one is performed. (Note: Per DOE Order 5400.5* [Ref. 4], *qualitative analyses are acceptable, in most instances, for ALARA judgements, especially where potential doses are well below the dose limit.)*

A4: Refer to the Silo 3 performance calculations in 40430-CA-0003 [Ref. 1].

Q5: *What are the preferred control options and what is the basis for their selection. Present results of optimization, as appropriate (e.g., weighting factors, environmental impacts, associated risks, costs and changes in cost, sensitivity analysis, changes in societal impact (doses), etc. for options). (Note: The primary methods used to control exposure shall be physical design features, such as filtration, confinement,*

etc. Administrative controls and procedural requirements shall be employed only as supplemental methods to control radiation exposure, unless physical design features are demonstrated to be impractical. For control of airborne radioactive material, the design shall be, under normal conditions, to avoid releases to the workplace atmosphere, the surrounding environment, and in any situation, to control the inhalation of such material by workers to levels that are ALARA; confinement and ventilation shall normally be used.

A5: Refer to the Silo 3 performance calculations in 40430-CA-0003 [Ref. 1].

Q6: *Environmental ALARA Decision. State the controls that constitute Environmental ALARA for the activity.*

A6: Refer to the Environmental Control Plan [Ref. 5] Fugitive dust is controlled in accordance with RM-0047 [Ref. 6]. Stormwater runoff is controlled in accordance with PL-3083 [Ref. 7]. Processing activities are conducted under cover.

Q7: *Implementation and monitoring. Describe the methods to be used to monitor achieved performance against desired targets (e.g., ambient air monitoring, stack monitoring, water monitoring, surveillance, reporting, etc.).*

A7: Continuous monitoring of particulate radionuclides and radon exiting the stack will be used to ensure compliance with radon emission limits. Wastewater will be sampled and analyzed to ensure it meets the AWWT acceptance criteria.

Q8: *Recommended actions (advise consideration of additional factors, control options, develop additional information, etc.).*

A8: Monitoring programs will be implemented as described in the Environmental Control Plan [Ref. 5].

Q9: *Justification for recommendations.*

A9: Monitoring is consistent with the Applicable or Relevant and Appropriate Requirements (ARARs).

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E-4.0 REFERENCES

1. 40430-CA-0003, Rev. 2, *Radioactive Particulate and Radon-222 Stack Release Considerations for the Silo 3 Remedial Action Project*, Flour Fernald; August 29, 2003

2. 40430-RP-0012, *Timed Estimate of Secondary Waste for Silo 3*, Fluor Fernald; September 5, 2002

3. 10 CFR 835, *Occupational Radiation Protection*, Title 10 Code of Federal Regulations, Part 835, DOE; July, 2001

4. DOE Order 5400.5, *Radiation Protection of the Public and the Environment*; Figure IV-1, *Surface Contamination Guidelines*; DOE, February 8, 1990

5. 40430-PL-0005, *Fernald Silo 3 Project Environmental Control Plan*, Fluor Fernald; October 13, 2003

6. RM-0047, *Fugitive Dust Control Requirements*, Fluor Fernald

7. PL-3083, *Storm Water Pollution Prevention Plan*, Fluor Fernald

Appendix F

APPENDIX F
FIRE HAZARD ANALYSIS

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ACRONYMS

DOE = U.S. Department of Energy

EPDM = Ethylene propylene diene monomer

FCP = Fernald Closure Project

HVAC = Heating, ventilation, and air conditioning

IBC = International Building Code

MCFL = Maximum credible fire loss

MPFL = Maximum possible fire loss

NFPA = National Fire Protection Association

OBC = Ohio Building Code

EXECUTIVE SUMMARY

The purpose of this document is to establish the design and operating features necessary to manage the risk of fire associated with operation of the systems within the Silo 3 Process Facility. The descriptions and conclusions are based on the preliminary design documentation. The Silo 3 Project is supported by the Fernald Closure Project (FCP) infrastructure services including water supply for fire protection and contracted emergency response. PCN2

Potential fire scenarios were analyzed for the Silo 3 Process Facility, including the maximum credible fire loss and the maximum possible fire loss. It was determined that fire suppression systems are not required for the Silo 3 Process Facility. Areas subject to contamination have been provided with a fire detection system to detect a fire in the incipient stage to alert personnel and the Crosby Township Fire Department, thus controlling the spread of fire. Fire detection and fire alarm systems are provided throughout the facility. DOE-STD-1066-99, Section 6.2.5 [Ref. 1], suggests that hose runs from hydrants to all exterior portions of protected buildings be no more than 300 ft. There are areas of the Silo 3 Project that exceed a 300 ft hose run from the closest hydrants; however, water pressure and hose diameter are sufficient to provide adequate protection. PCN2

Water supplies, fire reporting, and designated emergency response will likely change over the next few years during operation of the facility. Changes that have occurred include the demolition of the elevated water tank used for firewater and the supplementing of the site Fire Department with contracted services. Neither of these changes should jeopardize the level of protection required for the facility. Generally, except for the loss of the elevated tank, water supplies should be more abundant as existing sprinkler-protected facilities are demolished at the site. As a result of the readiness review, this document may require updating prior to facility operation to ensure that all changes are adequately addressed and that the level of protection is not diminished. Any change in the response times between the contracted services will be reviewed and evaluated, as required during service procurement. PCN2

The conclusion of this Fire Hazards Analysis is that the fire risk of the Silo 3 Process Facility are low to moderate and will be adequately controlled by the fire detection/alarms design and operating features provided. The objective of protecting the public and the environment from fire-induced releases is met. The objective of protecting employees from fire is accomplished with detection, notification, and means of egress. The property damage and project downtime risks are acceptable for the duration of this project.

F-1.0 INTRODUCTION

The following fire hazard analysis was prepared to satisfy DOE requirements for the proposed project. This effort was based on performing a fire hazards analysis as required by DOE Order 420.1, *Facility Safety* [Ref. 2]; and DOE Order 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees* [Ref. 3]. The subject project is located at the DOE FCP at Fernald, Ohio.

The intent of this analysis was to review the proposed project in accordance with the proposed design documents and determine what, if any, design modifications, enhancements, etc., would be necessary to the fire safety and life safety elements of the project.

The purpose of a fire hazards analysis is to comprehensively and qualitatively assess the risk from fire within individual fire areas in a DOE facility to ascertain whether the DOE fire safety objectives delineated in Order 420.1 and Order 440.1A are met.

DELETION PCN2

F-1.1 Purpose

The purpose of this document is to establish the design and operating features necessary to manage the risk of fire associated with operation of the Silo 3 Process Facility for the retrieval and packaging of the Silo 3 material.

The potential fire hazards associated with the processes, structures, facilities, and equipment are identified, and the fire prevention and protection strategies are outlined.

F-1.2 Approach and Assumptions

The descriptions and conclusions in this document are based on the design documentation. The Silo 3 Process Facility is supported by the FCP infrastructure services including fire protection and contracted emergency response. PCN2

A sprinkler system was not included in the design of the building for three chief reasons. First is the lack of combustibles. The main buildings are constructed primarily of steel and concrete. The combustible materials, e.g., insulation in the walls, roofing, and the membrane-covering meet code for fire resistance or are self-extinguishing. Most of the contents of the building are not combustible either. The few combustibles, listed in Section F-1.3 are widely dispersed so that the likelihood of fire spread is low. Second, in many areas contamination may be present and activation of a sprinkler head would cause its spread, greatly increasing the cost of recovery. Third is the duration of the project, scheduled for completion in less than 9 months from start to finish. DELETION PCN2

PCN2

F-1.3 Facility Use, Function, and Occupancy

The Silo 3 Facility is to receive, transfer, and package material from Silo 3 for shipment to an off-site disposal facility. The material is received as a powder and then is bagged for shipment and final disposal. The new facilities for which construction, operations, and maintenance activities are being performed include:

- Cargo Container Building
- Excavator Building
- Silo Enclosure Building
- Process Building
- Operations Support and Change Trailer
- Electrical Equipment Building

TABLE F.1-1 summarizes the few combustibles expected in the Silo 3 Facilities.

TABLE F.1-1: SILO 3 EXPECTED COMBUSTIBLES

Area	Normal Occupancy	Combustibles
Cargo Container Bay	2 to 4	Ferrous sulfate tank, FRP, 8'dia, 12' high, aqueous solution Sodium Lignosulfonate Totes (2), FRP, 4'x4'x4', aqueous solution Portable dike for one sodium lignosulfonate tote, HDPE, 250lbs 33 lb cylinder, propane on fork truck Product Shipping Bags, polypropylene, 4'x 6'x 4', @33 lbs Shipping Bag Liners, 30 mil polyethylene, 4'x 6'x 4',
Excavator Building	None	None
Silo Enclosure Building	2 during vacuum retrieval	Vacuum Hose
Process Building		
Packaging Area		Product Shipping Bag (2) polypropylene, 4'x 6'x 4', @33 lbs Shipping Bag Liners (2), 30 mil polyethylene, 4'x 6'x 4',
Overhead Areas	None	Baghouses (3) PTFE coated Polyethylene, in steel enclosure Cartridge Filter (1) PTFE coated filter paper, in steel enclosure
Wastewater Tank Area	None	Additive Mix Tank, FRP, 8' high, 6' diameter, aqueous solution inside Wastewater Storage Tank, FRP, 8' high, 6' diameter, aqueous use Additive Charge tanks (2), FRP, 3'6" high, 3' diameter, aqueous use Ferrous Sulfate Pump, (1) HDPE pump, 20 lbs, Internal $FeSO_4$ use

TABLE F.1-1: SILO 3 EXPECTED COMBUSTIBLES		
Area	**Normal Occupancy**	**Combustibles**
Corridor	Personnel access	None
Other Areas		
Entry Corridor	Personnel Access	None
Trailer	2 to 4	Normal furniture and office use items
Electrical Building	Maintenance Only	None

The Silo 3 Process Facility has been divided into four contamination zones to classify the probability of contamination:

Zone 1: High Contamination Areas, Silo 3 and the Excavator Room of the Excavator Building: where radioactive material is exposed to air.

Zone 2: Contamination Areas, Excavator Service Area of the Excavator Building and portions of the DOFF Area of the Process Building, which provide access to Zone 1 space: potential radioactive contamination.

Zone 3: Buffer Area, portions of the DOFF Area, Corridor, Bagging Room, and Unloading Areas of the Process Building: normally occupied general working areas for operations and maintenance.

Zone 4: Controlled Areas, Cargo Container Building, Operations Support and Change Trailer, and the Electrical Equipment Building: where radioactive contamination is prohibited.

These contamination zones are shown on the Jacobs Safety and Health Drawings 94X 3900-M-01557 thru 94X-3900-M-01559 [Refs. 4, 5, and 6].

A more detailed description of the strategy and equipment to be used to remove the material contained in Silo 3 is found in 40430-PL-0002, *Access and Retrieval Strategy for the Silo 3 Project* [Ref. 7], and in 40430-RP-0003, *Process Description for the Silo 3 Project* [Ref. 8].

Jacobs Drawing 94X-3900-M-01461 [Ref. 9] shows the General Arrangement Plot Plan for the Silo 3 project.

The Silo 3 Process Facility is planned to operate 12 hours per day, 4 days per week from its initial operation throughout the duration of the project. When necessary, the work schedule will change as required in order to meet the site and project objectives.

F-1.4 General Site Fire Protection

The Silo 3 Project facilities are located on the western side of the FCP site. Water for fire protection will be available from the FCP site from two automatically initiated centrifugal pumps; each rated to deliver 1,250 gallons per minute (gpm) at 123 pounds per square inch gauge (psig) taking their suction from a 400,000 ground level tank. The FCP Fire Protection Engineering Department conducted a flow test on the fire hydrant, HFH-165, for the Silo 3 area on November 18, 2000. The test showed that the hydrant, HFH-165, is capable of a capacity of 1,890 gallons per minute at 92 psig to support fire suppression activities. The Crosby Township Fire Department will provide fire emergency response. PCN2

The Silo 3 Civil Utility Plan, Drawing No. 94-X-3900-G-01299 [Ref. 10], shows a site plan for the project and the fire hydrant HFH-165 location.

F-2.0 CONSTRUCTION

F-2.1 Type of Construction

The Silo 3 Process Facility is designated as Type IIB Construction. This type of construction is allowed per Table 602, Ohio Building Code (OBC) 2002. Per OBC 2002, p. 85 Section 503.1.2- Special Industrial Occupancies is exempt from the area and height limitations for this type of occupancy classification.

The process facility is designed with approximately 5,700 ft^2 first floor areas, which includes the packaging and processing areas as well as the cargo container loading area. The exterior of the areas is constructed using an insulated metal panel system on metal girt or furring channels. The insulation is foamed-in-place polyurethane surrounded by 26-gauge, G90 zinc-coated steel. The interior walls in the Process Building are the interior metal liner of the exterior siding. The roof system consists of a single-ply ethylene propylene diene monomer (EPDM) roofing system with insulated boards on metal roof deck. The height of the roof elevations of the packaging and processing areas ranges from 24 ft high to 50 ft high. The EPDM roofing system meets Factory Mutual Class I fire standards. PCN2

Exterior and interior personnel doors are insulated 14-gauge, and exterior-coiling doors are insulated flat metal slats. Radiation shielding is not required for the interior and exterior coiling doors.

A tension frame fabric structure encloses Silo 3 to provide weather protection. This enclosure has a footprint of approximately 10,000 ft^2. The height of the roof elevations for the enclosure ranges from 36 ft high up to 49 ft high.

The Excavator Room and Excavator Service Area walls are poured-in-place concrete.

A trailer is used for Operations Support and a Change Room.

An insulated metal building is used for the Electrical Building.

F-2.2 Fire Barrier Separation

PCN2

The corridor is designed to meet 1-hour fire-resistive construction. The vestibule is not required to have a 1-hour rating per Life Safety Code [Ref. 11], NFPA 101, Chapter 40.3.6, *Corridors*.

F-2.3 Interior Finishes

Interior finishes for all occupied facilities meet the requirements of the National Fire Protection Association (NFPA) 101, *Life Safety Code* [Ref. 11], Fire Standard DOE-STD-1066-99 [Ref. 1], and Standard NFPA 801 [Ref. 12].

F-3.0 LIFE SAFETY

An architectural code review [Ref. 13] has been prepared for the facility that evaluates the life safety issues discussed below. Summary statements are included in the following sections as appropriate.

F-3.1 Occupancy Classification

PCN2

The Silo 3 Process Facility has an occupancy classification of Factory Industrial Occupancy F-2 (Low Hazard). This classification is based upon criteria contained in the 1998 OBC, Table 307.8(2), Exempt Amounts of Hazardous Materials Liquids and Chemicals Presenting a Health Hazard. The 2002 OBC did not have exempt amounts quantified to determine threshold limits. The International Building Conference was consulted to determine the correct method of determine Occupancy based upon the facility use. Doses from a single exposure were found to be substantially less than the values in Table 307.8(2).

F-3.2 Means of Egress

The number of exits, the exit width, travel distance, and exit locations are in accordance with NFPA 101, *Life Safety Code*, and the Occupational Safety and Health Administration 29 CFR 1910, Subpart E [Ref. 14].

Because of the requirements for containment walls and necessary rapid evacuation in case of uncontrolled material releases, the Silo 3 facility has been made handicapped-accessible in the cargo container area. The excavator room, packaging line, and wastewater tank area have ground floor accessibility.

PCN2

F-3.3 Emergency Lighting and Exit Lights

Emergency lighting has been provided in accordance with NFPA 101 and the International Building Code (IBC) 2000. Exit lights marking the means of egress have been provided in accordance with NFPA 101. Emergency lighting locations are noted on Jacobs Electrical Drawing No. 94X-3900-E-01585 [Ref. 15].

F-3.4 Security Interaction

Existing security provisions for these facilities will not impede the safe evacuation of the facilities or emergency response.

F-3.5 Radiation and Contamination Control

Existing health physics and radiation protection features will not impede the safe emergency evacuation.

F-4.0 FIRE HAZARDS

F-4.1 Waste Characterization

The material in Silo 3 is primarily metal oxide salts and is classified as 11(e)(2) byproduct material under the Atomic Energy Act of 1954. It consists of dried metal oxide salts produced from a calcining operation. Because of the evaporation and calcination of this material, the water content is very low, ranging between 3.7 and 10.2 percent. In one test, approximately 90 percent (by weight) of the material passed through a 200-mesh sieve (0.074 mm), indicating the presence of submicron particles. The bulk density of the Silo 3 material ranges from approximately 29 lb/ft^3 to 58 lb/ft^3. Based on 40430-DC-0001, *Design Basis and Requirements Document for the Silo 3 Project* [Ref. 16], the material is not combustible or explosive because it is a metal oxide. See **FIGURE F.4-1**.

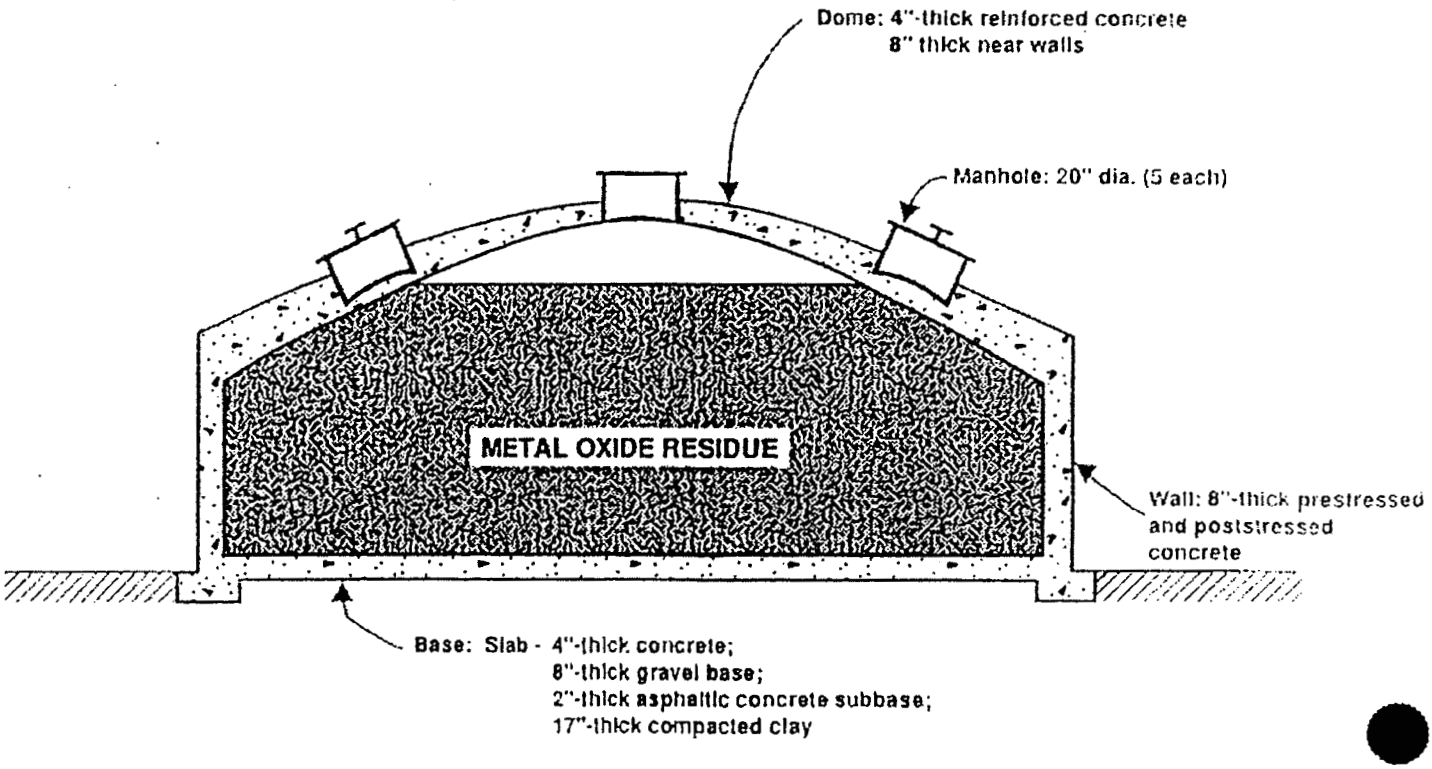

FIGURE F.4-1: CROSS SECTION VIEW OF SILO 3

F-4.2 Auxiliary Systems

Utilities

Electrical power is provided from the Electrical Equipment Building, which is located approximately 14 ft to the northwest of the Process Building. There is a transformer, motor control center, and an uninterruptible power supply.

PCN2

The electrical system is designed to meet NFPA 70, *National Electrical Code* [Ref. 17].

No fuel-fired equipment (e.g., boilers, kilns) is used for the Silo 3 Project within the Silo 3 Process Facility.

A propane-fired, 6,000 to 8,000 pound capacity fork truck will be used in the cargo container bay. The standard 33-pound propane cylinder meets industry standards and would release the propane if overheated. The propane is listed as a combustible in Section F-1.3.

The packaged air conditioning units for the Process Building and the Cargo Container Bay Air Handling Unit have smoke detectors installed in their supply air plenums. The air conditioning units and air-handling unit will be shut down when a fire is detected by the fire detection system by a signal sent from the fire detection system. The Silo Enclosure and the Process Building have exhaust fans that will also be shut down when a signal is received from the fire detection system. Motorized fire dampers are located in the ductwork for the corridors and the air locks. See Section F-4.5 for a description of a fire-induced radiological dispersal. A detailed description of the strategy and equipment used for the heating, ventilation and air conditioning (HVAC) of the facilities is described in the HVAC Sequences of Systems Operations drawings [Refs. 18 and 19]. PCN2

Process Equipment

A detailed description of the strategy and equipment used to remove the material contained in Silo 3 is found in the project *Access and Retrieval Strategy for the Silo 3 Project*, Document No. 40430-PL-0002 [Ref. 7] and the *Process Description for the Silo 3 Project*, Document No.40430-RP-0003 [Ref. 8]. From a fire protection standpoint, none of the processes or equipment pose a combustible materials loading hazard. PCN2

The Process and Excavator Buildings contain process equipment, including pumps and motors that create a low risk of a localized fire. The buildings also contain hydraulic, pneumatic, and electrical systems, creating a small potential for localized fires. The hydraulic oil is a combustible liquid with a flash point of 350°F or greater. An electric motor could fail and become an ignition source for other combustibles including hydraulic fluids. However, the likelihood of an ignition of hydraulic oil is low because of the high ignition energy required and the need for a second failure (motor failure). No other significant ignition sources (e.g., heated surfaces) are in proximity of the hydraulic systems. An electrical or hydraulic fluid fire would render the affected equipment inoperative until repairs could be made. The amount of combustible materials is not adequate to create a fire capable of causing structural damage to the buildings.

Operations Support and Change Trailer

The Operations Support and Change Trailer presents a moderate fire risk due to the electronic equipment located in the Control Room in the northeast corner and storage in the southwest corner. Walls of the trailer are fabricated using combustible materials. The Change Room in the northwest corner is standard light hazard occupancy and presents no significant fire risk. This area (Fire Area 2) is separated from the Silo 3 Process Building by an enclosure of approximately 14 ft by 25 ft dimensions. The enclosed area is an extended exit corridor from the Silo 3 Building. The trailer is positioned 3 ft 9 in away from the tension frame fabric structure over Silo 3. The trailer is a temporary structure (having non-rated walls and being un-sprinklered) and therefore does not need to meet Table 600 of the Ohio Building Code for fire separation. The fabric on the tension structure is flame retardant, self-extinguishing, and does not propagate flame. The structure design also allows the self-venting release of heat.

F-4.3 Analysis of Potential Fire Scenarios

- Fire Area 1 – Process, Excavator, and Cargo Container Buildings: The Process, Excavator, and Cargo Container Buildings have been constructed of noncombustible materials and contain a very limited amount of combustible materials. The worst-case fire in this building would be in the packaging/filling area of the process building due to the presence of packaging materials, conveyors, and motors in proximity to each other. An uncontrolled fire in this area could create significant damage to the equipment and the building, thus impacting the operation of the facility. PCN2

- Fire Area 2 – Operations Support Area: The fire scenario in this area involves the Operations Support and Change Trailer, which are considered to have a moderate hazard occupancy. A fire could do significant damage to the trailer because of the equipment inside. Building materials for stairs and decks that meet applicable codes are used to minimize the potential for a fire to propagate from the trailer to the process building. In addition, the trailer is normally occupied during operations, so that personnel would be immediately available to fight an incipient fire. The enclosed area between the trailer and Process Building is rated for one-hour construction. PCN2

  A fire in the Operations Support and Change Trailer might propagate to the tension support structure covering Silo 3. However, structure ventilation, a flame retardant fabric, fire alarms, and the time required for a fire to breach the Operations Support and Change Trailer's outer envelope would provide for sufficient worker safety and minimize equipment damage. The fabric cover for the tension support structure is self-extinguishing PVC with a Flame Spread Rating of 25 or less and a Flame Resistance of 2 seconds or less.

F-4.4 Explosives

None of the materials handled or used in the Silo 3 Process Facility Project in any measurable quantities create an explosive hazard based on the hazard category calculation in Appendix B of this N-HASP.

F-4.5 Potential for Radiological, Biological, or Toxic Incident

- Radiological Hazards: The major radiological hazard from a fire would be the potential release of radon from the packaging area. The calculation of the worst-case dose to a worker or a member of the public in the event of a spill of material from equipment failure due to a fire is based on the assumed complete release of the radon present in the spilled material. Radon in the spilled material void spaces, radon generated over the next 24 hours, and some of the solids are released to the ventilation system. The filter system fails to remove the material and all materials are passed through the ventilation system and released from the 125 ft stack. The calculated dose at 350 m downwind was found to be 12 mrem. Therefore, a fire in the packaging area of the process building should not be considered to be "safety-significant." DELETION PCN2

- Biological Hazards: There are no biological hazards created by any fire scenario.

- Chemical and Toxic Hazards: Two chemicals will be used in the process, ferrous sulfate and sodium lignosulfonate. Both chemicals will be supplied as aqueous solutions and will remain in solution (in an even more diluted form) during use. Ferrous sulfate is not combustible, and sodium lignosulfonate will only burn if dried out. With the detection/alarm systems provided, none of the fire scenarios should involve the release of hazardous or toxic chemicals.

F-4.6 Fire Protection Water Run-Off

Water for fire fighting would only be used in the non-contaminated areas of the facility. Therefore, this should not create a contaminated water run-off problem greater than normal storm water run-off, since no breach of contaminated areas would occur.

F-4.7 Natural Hazards (Earthquake, Flood, and Wind)

Wind is the only natural hazard that could exacerbate a fire by allowing a fire to propagate between the trailer and the Process Building (Section F-6.4, MPFL). Earthquake and flood potentials do not affect the fire risks.

F-5.0 FIRE PROTECTION

F-5.1 Water Supply

An adequate fire-protection water supply is available from the FCP site (Section F-1.4). Fires in areas that cannot be handled with portable fire extinguishers will be suppressed manually by the subcontracted fire department. The Silo 3 Civil Utility Plan, Drawing No. 94-X-3900-G-01299 [Ref. 10], outlines the site plan and the fire hydrant locations. PCN2

F-5.2 Fire Suppression

The Implementation Guide for DOE Orders 420.1 and 440.1 (paragraph 9.7) [Ref. 20] states that DOE has an obligation to provide protection for its facilities so that a fire will not result in an unacceptable program delay or property loss. Consequently, DOE considers any facility in excess of 5,000 ft^2 in ground floor area and any facility with a maximum possible fire loss (MPFL) of $1 million ($10 million approved at FCP via DOE memorandum, DOE-0320-99 [Ref. 21], J. Craig to G.L. Denver, January 22, 1999, *Change in Maximum Possible Loss Criteria at the Fernald Environmental Management Project*) as warranting protection by an automatic fire suppression system. The packaging area of the Silo 3 Process Building has a ground floor area of 5,700 ft^2 and Occupancy Classification of Group F-2 (Low Hazard). Group F-2 Occupancies do not require that an automatic sprinkler system be provided. On Feb. 1, 2000, a DOE memorandum provided FCP with a fire suppression system exemption [Ref. 22]. A fire detection and alarm system has been installed throughout the Silo 3 facility to assure occupant notification of emergencies. Fire extinguishers are provided throughout the Silo 3 facility. They are located external to the PCN2

fire hazard areas and near access ways so that incipient fires can be extinguished.
DELETION

Fire suppression for the trailer emphasizes manual fire fighting. Normally-occupied areas have been provided with fire detection and alarm systems to assure prompt notification of emergencies to both occupants and to subcontracted emergency response. Portable fire extinguishers have been provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers* [Ref. 23]. Because of the lack of continuity of combustibles and the provisions of the fire detection system (see Section F-5.3), credible fires will be incipient in nature and can be suppressed using portable extinguishers. Because of the limited size and low or moderate hazard use, no automatic sprinkler protection is required. A trailer fire that is not controlled with portable extinguishers will require hose lines operated by the subcontracted fire department. The water supply distribution system to the Silo 3 area is a dead end run hydrant. This dead end run hydrant is within 290 ft of the supply tie-in point. There are parts of the Silo 3 Project that exceed the suggested maximum hose run distance of 300 ft distance from a hydrant, as specified in DOE STD 1066-99, Section 6.2.5 [Ref. 1]. However, water pressure and hose diameter are sufficient to provide adequate protection. The parts of the facility that fall outside this suggested hydrant support area are the Operations Support and Change Trailer, and the north and northwest sides of the Silo 3 Enclosure.

PCN2

PCN2

F-5.3 Protective Signaling System

Fire Detection

The Silo 3 Process Facility has been provided with fire detection and alarm systems to assure prompt notification of fire emergencies to both building occupants and emergency responders.

Detectors have been installed in accordance with NFPA 72, *National Fire Alarm Code* [Ref. 24], and are connected to the Silo 3 Process Building Fire Alarm Control Panel.

PCN2

Fire Alarm System

The fire alarm system has a central Fire Alarm Control Panel in the Silo 3 Process Building. A fire or trouble alarm will be sent to the Savannah River Facility Communication Center, which will relay the alarm to the FCP site. Manual pull boxes have been installed in accordance with NFPA 72 and the IBC. Notification devices consist of horns and strobes and are installed in all areas in accordance with NFPA 72.

Smoke Detection System

Industrial grade smoke detectors powered by 24V with battery back-up have been installed in the facility. Photoelectric spot type smoke detectors have been installed in the Cargo Container Bay, Packaging Area, Storage Area, Waste Water Area, Electrical Building, Operations Support and Change Trailer, Corridors, Air Locks, supply air plenums for the air conditioning units and the Cargo Container Bay Air Handling Unit. Linear Beam

PCN2

type smoke detectors have been provided for the Silo Enclosure. Each is wired to a fire alarm control panel. Automatic notification will be sent to the communication center. Activation of any smoke detector will sound a general alarm throughout the facility. PCN2

Heat Detection System

Combination rate-of-rise/fixed temperature type heat detectors have been installed above potentially dusty areas (i.e., rubber belt conveyors, within the air handling system, and in the Excavator Room). Each heat detector has a discrete address, will sound a general alarm, and automatically notify the communication center when activated. PCN2

F-5.4 Fire Department Response

Fire pre-plans have been developed for each fire area to outline the fire-fighting strategies and precautions required for the Silo 3 Process Facility. These pre-plans have been developed and reviewed with the Crosby Township Fire Department. Selected Silo 3 Process Facility project employees will receive incipient fire training regarding portable extinguishers and the alarm system. PCN2

F-6.0 FACILITIES, EQUIPMENT, AND PROGRAM PRESERVATION

F-6.1 Essential Safety Class Systems

No systems are considered essential safety class systems for this project as determined per the Silo 3 accident analysis in Appendix G of this N-HASP.

F-6.2 Vital and Critical Program

Vital Program Impact

A fire in the Process Building would be local and involve only one piece of equipment due to the lack of combustibles and their separation. As a result, recovery would not be more damaging to cost and schedule than other events such as the failure of containment (and the spread of contamination) or equipment failure. Areas where there are combustibles are areas where there is usual occupancy so that personnel would likely be available to mitigate the incipient fire immediately. In addition, the fire detection devices and alarms provided in these areas would alert others to help minimize damage and downtime.

Primary Equipment

All components involved with the retrieval, conveyance, and packaging of silo material are primary equipment. The fire detection system reduces the significance of a fire involving any of these components. PCN2

F-6.3 High-Value Equipment

The following values were obtained from estimates and procurements to date:

- Inclined conveyor: $125,000
- Packaging system bag loaders: $400,000
- Package heat sealers: $320,000
- Excavator: $450,000
- Pneumatic Retrieval - Vacuum Blower Skid: $100,000
- Pneumatic Retrieval Collector: $120,000
- Pneumatic Retrieval Cartridge Filter: $65,000
- Motor control centers: $125,000
- 480-volt feeder: $81,000
- Control System: $200,000
- Continuous emissions monitor: $90,000
- Personnel contamination monitors: $90,000
- Tennelec counting systems: $90,000
- Process Vent System Collectors: $90,000
- HVAC: $275,000
- Trailer: $135,000
- Tanks: $90,000

F-6.4 Facility Fire Loss Potential

The maximum credible fire loss (MCFL) and MPFL potential in each fire area includes the cost of property loss, recovery, cleanup, and replacement.

Maximum Credible Fire Loss

- Fire Area 1 – Process, Excavator, and Cargo Container Buildings, and Silo 3 Enclosure: The MCFL is a fire in the packaging area of the Process Building that would result in damage to one of the two Container Management and Packaging Systems. The

property damage would be approximately $800,000. Because of the redundant container management and packaging systems this MCFL would have little programmatic impact on the project.

- Fire Area 2 – Operations Support Area: The MCFL is a fire in the Operations Support and Change Trailer. An electrical fire could do significant damage to the trailer and control systems because of the trailer's frame construction. The property damage would be approximately $900,000. This MCFL would have a programmatic impact on the project.

Maximum Possible Fire Loss

- Fire Area 1 –Process, Excavator, and Cargo Container Buildings, and Silo 3 Enclosure: The MPFL is a fire in the packaging area of the Process Building that would result in the loss of the Container Management and Packaging Systems, as well as all ancillary equipment. The property damage would be approximately $2,500,000. This MPFL would have a programmatic impact on the project because the majority of the equipment is not readily replaceable.

- Fire Area 2 – Operations Support Area: The MPFL is an unmitigated fire in the trailer during high wind conditions and is the same as the MCFL for this area. The resulting damage would include the trailer with similar property damage of approximately $900,000. This MPFL would have a programmatic impact on the project, but these facilities and associated equipment are more readily replaceable than those associated with Fire Area 1.

F-6.5 Emergency Planning

The Silo 3 Process Facility Project emergency planning will be integrated with PL-3020, the FCP Emergency Plan [Ref. 25], EM-0030, *Silos Area Emergency Procedure* [Ref. 26], and EM-0020, *Building Emergency Procedure* [Ref. 27]. PCN2

F-7.0 CONCLUSION

The conclusion of this Fire Hazards Analysis is that the fire risk of the Silo 3 Process Facility are low to moderate and is adequately controlled by the fire detection/alarms design and operating features provided. The objective of protecting the public and the environment from fire-induced releases is met. The objective of protecting employees from fire is accomplished with detection, notification, and means of egress. The property damage and project downtime risks are acceptable for the duration of this project.

A small, localized fire in the contamination areas (see Section F-1.3) will be detected in the incipient stage and can be controlled with portable fire extinguishers and/or the ventilation system to isolate the areas. DELETION PCN2

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F-8.0 REFERENCES

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23. NFPA 10, *Standard for Portable Fire Extinguishers,* National Fire Protection Association

24. NFPA 72, *National Fire Alarm Code,* National Fire Protection Association

25. PL-3020, *FEMP Emergency Plan*, Fluor Fernald

26. EM-0030, *Silos Area Emergency Procedure,* Fluor Fernald

27. EM-0020, *Building Emergency Procedure,* Fluor Fernald

Appendix G

APPENDIX G
ACCIDENT ANALYSIS

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ACRONYMS

ARF = Airborne release fraction

ARR = Airborne release rate

ASR = Auditable safety record

CEDE = Committed effective dose equivalent

Ci = Curie

DAC = Derived air concentration

DCF = Dose conversion factor

DOE = U.S. Department of Energy

EBA = Evaluation basis accident

EG = Evaluation guideline

ERPG = Emergency Response Planning Guide

FCP = Fernald Closure Project

HC = Hazard category

HEPA = High-efficiency particulate air

MOI = Maximally exposed off-site individual

OU = Operable unit

pCi = Picocurie

PHAR = Preliminary Hazard Analysis Report

RF = Respirable fraction

STD = Standard

TPQ = Threshold planning quantity

UCL = Upper confidence level

WL = Working level

WLM = Working level-month

EXECUTIVE SUMMARY

The purpose of this accident analysis is to determine if any safety-class structures, systems, and components or technical safety requirements are needed for protection of the public. The analysis quantifies the consequences of potential hazards associated with the activities supporting the Silo 3 project and compares the consequences to U.S. Department of Energy (DOE) Evaluation Guidelines.

Analysis of five accident scenarios produced the radiological dose estimates for collocated workers and off-site populations. The nearest off-site point on the Fernald Environmental Management Project site boundary is approximately 350 m west of the silos. The maximally exposed off-site individual is assumed to be located 350 m downwind of the accident location. The committed effective dose equivalents are estimated in this appendix for individuals located at 30, 100, and 350 m from the point of the release. The values at 350 m are compared to the Evaluation Guidelines (EGs) established by DOE-STD-3009-94, Appendix A [Ref. 1].

The conclusion that can be drawn from the analyses is that none of the accident scenarios analyzed yield consequences that would require "safety-class" controls per DOE-STD-3009-94, Appendix A.

G-1.0 INTRODUCTION

The purpose of this Accident Analysis is to support the final hazard categorization and to determine if any safety-class structures, systems, and components (SSC) or technical safety requirements are needed for protection of the public. Safety-class SSCs will not normally be associated with Hazard Category 2 or 3 facilities due to their limited potential for offsite impact. The analysis quantifies the consequences of potential hazards associated with the retrieval and packaging of the material in Silo 3 including construction and operation of the processing areas and storage of retrieved material. The bounding accidents for the Silo 3 project are fully analyzed and reported in this document for comparison to the DOE-STD-3009-94, Appendix A [Ref. 1] Evaluation Guideline (EG). Safety-class SSCs are required for consequences exceeding an EG of 25 rem total effective dose equivalent to a maximally exposed off-site individual (MOI).

Safety-significant SSCs are those important to defense in depth or onsite worker safety. Although EGs are not used for designating safety-significant SSCs, the onsite impacts are determined in this analysis.

Within this analysis, consequences are determined for:

- workers at 30 m, which represents the distance for determining the dose threshold criteria of DOE Hazard Category (HC) 3 facilities.
- workers at 100 m, which represents the distance for determining the dose threshold criteria of DOE HC-2 facilities.
- The public at 350 m, which is the distance to the MOI. This distance corresponds to the nearest site boundary. The MOI distance is used for comparison with off-site EG.

The scope of the analysis is focused on the accidents most likely to be encountered during the operation, and maintenance of the Silo 3 retrieval and disposition project.

G-2.0 ACCIDENT ANALYSIS METHODS

This section presents the results and major assumptions for the analysis of five evaluation basis accident (EBA) scenarios associated with the facility. As determined by the hazard category calculations in APPENDIX B, the Silo 3 activities constitute, at most, a "radiological" facility, and accident analyses are not essential. However, these analyses are presented to 1) demonstrate that consequences of accidents would not result in significant localized consequences, and 2) help in determining defense-in-depth controls. The accident scenarios considered are:

- EBA-1: Hose rupture during pneumatic retrieval
- EBA-2: Silo wall containment failure during cutting an opening in the silo wall
- EBA-3: Spill of material from a conveyor failure
- EBA-4: Breach of full soft-sided package
- EBA-5: Failure of the collectors/filters in the pneumatic retrieval system

The locations of scenarios are described in SECTION G-3.0.

G-2.1 Basic Calculation Method for Solids Release

The methods used to determine the dose consequence or committed effective dose equivalent (CEDE) for each accident scenario use variations of the following general equation from DOE-HDBK-3010-94 [Ref. 2]:

$$CEDE = \sum (MAR * DCF * DR * BR * ARF \text{ or } ARR * LPF * RF * (\chi/Q) * T)_i$$

where:

MAR	=	The amount of a radionuclide available to be acted upon by a physical stress (pCi)
DCF	=	dose conversion factor in mrem/pCi
DR	=	damage ratio or the fraction of the MAR actually impacted by accident conditions
BR	=	breathing rate of a reference person considered 3.33×10^{-4} m^3/sec
ARF	=	airborne release fraction
ARR	=	airborne release rate
LPF	=	leak path factor or the fraction of material transported through some confinement
RF	=	respirable fraction
χ/Q	=	long-term dispersion factor in sec/m^3
T	=	exposure time in hours
i	=	each radionuclide

The dispersion factor (χ/Q) for a straight line, ground level release, is determined from a Gaussian plume model for continuous point source emission from the *Handbook of Health Physics and Radiological Health* [Ref. 3]. A wind speed of 1.0 m/second and D stability class was used at a distance of 30 m, which is consistent with the recommendations of DOE-STD-1027-92 [Ref. 4], for HC 3 criteria. A wind speed of 4.5 m/second and D stability class was used at 100 m, which is consistent with the recommendations of DOE-STD-1027-92 for HC-2 calculations. A wind speed of 1.0 m/second and F stability class was used at 330 m, which is consistent with the requirements of DOE G 151.1-1, *DOE Emergency Management Guide: Hazard Surveys and Hazard Assessments* [Ref. 5].

For a continuous release, the receptor is assumed to be exposed for 24 hrs at 30 m and 2 hrs at 100 m and 350 m. For an instantaneous release, the material is assumed to be completely released within 1 hour. The receptor is exposed during this hour to the instantaneous release, and for the entire exposure period to resuspended solids that are emitted continuously. PCN2

In some accident scenarios, contaminants are released to the environment from a 125-ft stack that will be built as part of the Silo 3 project. To estimate the upper bound of the effect of such releases, a "fumigation" model is adopted from the *Handbook of Health Physics and Radiological Health*. Under this model, releases from the stack are constrained to mix under an inversion layer with a "lid" assumed at a height of 100 m.

The model specifies a stability class G and wind speed of 1 mph (0.5 m/second) to reflect an extreme nighttime inversion.

For evaluation of chemical consequences, the hazard category calculations in **APPENDIX B** have indicated that only five hazardous chemicals exceeded the 40 CFR 355 threshold planning quantities. These include arsenic, cadmium, mercury, thallium, and vanadium. Therefore, for EBAs in which solids are assumed dispersed, the concentration of each of these contaminants at the receptor is determined for comparison with evaluation guidelines by the following equation:

$$C\ (mg/m^3) = MAR * ARF * RF * DR * LPF * (\chi/Q)/\text{time of release}$$

G-2.2 Basic Calculation Method For Radon Release

Fluor Fernald developed a predictive tool, *The Fernald Radon Model,* to estimate radon air concentrations at different site locations for various release scenarios. The model, which reasonably fits existing site monitoring data, is described in the *Radon Modeling Report for the OU4 Safety Analysis Plan* [Ref. 6]. The model predicts the radon concentrations downwind from a release and allows inclusion of a "lag" term. The "lag" model is more complex, and provides a more accurate depiction of radon transport when compared to existing monitoring data. This is because the model accounts for the persistence of radon in the vicinity closest to the release point. The nonlag model is used for the accident analyses. The model, embodied in Equation 16 of the Radon Modeling Report, is based on F Class meteorological stability. A wind speed of 1.8 m/second is used in the accident analysis, since this speed is a basic assumption of the model and is based on the F Class stability. Once the radon air concentrations are determined at different receptor locations, the dose consequence can be determined.

The concentrations of radon progeny are calculated in working levels (WLs) in the manner specified by Evans [Ref. 7]. Exposures to these radionuclides are expressed in working level months (WLMs), that is, the time integrated concentration at the point of interest.

In several accident scenarios, the radiological source term released is initially pure ^{222}Rn, which by itself is not a great hazard. However, the radon quickly produces a chain of radionuclides, each the progeny of the previous parent. The conservative data provided by Fluor Fernald in Figure 8 of *An Evaluation of the Need for Personnel Radon Monitoring at the FEMP* [Ref. 8] shows that in a matter of a few hours, 100 pCi/L of ^{222}Rn will produce approximately one WL.

For the purpose of comparison with thresholds and limits, the dose equivalence of working levels must be determined. As shown in 10 CFR 835 [Ref. 9], the Derived Air Concentration (DAC) for Rn-222 is 30 pCi/L, corresponding to 5 rem in one year, which is equivalent to 2.5 mrem in one hour. Therefore, an individual exposed to 100 pCi/L Rn-222 (or 1 WL) for one hour would receive a dose of 7.5 mrem, assuming 100 percent progeny equilibrium.

G-2.3 Common Assumptions

The accident scenarios were analyzed using several common assumptions:

- The Silo 3 material is assumed to contain 3,870 pCi/g of ^{226}Ra and its progeny are in complete equilibrium unless otherwise noted in the scenario.

- The Silo 3 material bulk density ranges from 29 to 58 lb/ft^3. The average bulk density is 42.4 lb/ft^3 (0.68 g/cm^3). A bulk density of 50 lb/ft^3 was used in the analyses, conservatively bounding the average. This ensures that an operational condition does not occur in which the safety basis may be inadequate, or results in a "potential inadequacy of the safety analysis".

- All Silo 3 material is in powder form. The airborne release fraction (ARF) and respirable fraction (RF) of the solid powder material is obtained from DOE-HDBK-3010-94 [Ref. 2]. The inputs are summarized in **TABLE G.2-1**. The bounding ARF for a free-fall spill of uncontained powders, page 4-77 of DOE-HDBK-3010-94, is 2×10^{-3}. An RF of 0.3 was used for free fall spill of powders. These values were obtained from experiments performed using up to 1,000 g. TiO_2, material density 4.2 g/cm^3, from a spill height of 3 m. Recalculation of EBAs where free-fall spills were modeled was performed with more conservative bounding values, as discussed in SECTION G-3.0.

- The ARF for powders impacted by a falling object is 1×10^{-3} and the RF is 0.1. DOE-HDBK-3010-94, page 4-85, provides a basis for choosing an ARF and RF from impacts due to large falling objects and induced air turbulence. Tests were performed on a variety of materials to simulate the release of powders. All the tested materials were free-flowing (non-cohesive) powders, the most dispersible of which was Al_2O_3, with an ARF of 1×10^{-3}. The nature of this release scenario is to provide some confinement of its inner volume. DOE-HDBK-3010-94 also considers other material configurations in which some material protection is available. Additional tests were performed by dropping heavy objects on cans of powder. The highest RF value from the contained set was 0.07. DOE-HDBK-3010-94 concludes that, in cases where some material protection is afforded, the appropriate bounding ARF*RF is the highest ARF from the uncontained data set (1×10^{-3} for uncontained Al_2O_3) used in conjunction with the largest RF from the contained experiments (rounded to 0.1). As a result, an ARF of 1×10^{-3} with a RF of 0.1 was assessed to be appropriate for this release scenario.

- The airborne release rate (ARR) due to aerodynamic resuspension of spilled powders due to ambient wind stresses is detailed on page 4-96 of DOE-HDBK-3010-94. The ARR is assumed to be 4×10^{-5}/hr and the RF is 1.0.

- The summation of CEDEs for each radionuclide results in a CEDE for Silo 3 material of 19.8 rem/g inhaled (without radon and daughters). This is shown in **TABLE G.2-2**. The DCFs were obtained from Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion* [Ref. 10], which is based on ICRP 30. The selected lung clearance class was based on the presence of oxides. The Ra226 DCF, lung clearance

class Y, is obtained from CAP88-PC Version 2.1, which was determined using the RADRISK code. Short-lived radionuclides are not included because of the negligible dose contribution.

Radon will continue to emanate from silo material that is involved in spills or is open to the environment. The radon emanation rate from a solid material is 35 percent of the generation rate, based on experimental studies [Ref. 11 and 12]. The measured values for emanation fraction are derived or measured from mill tailings, which are similar to Silo 1 and 2 material in terms of composition, particle size, density, and porosity. However, Silo 3 contains calcined material that has a significantly different porosity, density, and particle size distribution. Since an experimentally determined emanation rate does not exist for Silo 3 material, 35 percent was used. The 35 percent emanation rate is the best experimentally based value available, although it may not be conservative.

TABLE G.2-1: DISPERSION ANALYSIS INPUTS

Release Mode or Type	Distance (m)	Application	Wind Speed (m/sec)	Stability Class	ARF	RF
Gaussian Ground Level Solids Release	30	HC-3	1.0	D	2E-3	0.3
	100	HC-2	4.5	D		
	350	MOI	1.0	F		
Gaussian Stack Solids Release	30	HC-3	1.0	D	2E-3	0.3
	100	HC-2	4.5	D		
	350	MOI	1.0	F		
Radon Release	30	HC-3	1.8	F	1	1
	100	HC-2				
	350	MOI				

Notes:
1. An ARF of 1×10^{-3} and an RF of 0.1 is used for EBA-2.
2. An ARR of 4×10^{-5}/hr and an RF of 1.0 is used for resuspension during EBA-6.

TABLE G.2-2: SILO 3 MATERIAL DOSE CONVERSION

Nuclides	95% UCL Specific Activity [a] (pCi/g)	Fed Guide 11 Inhalation DCF [b] (mrem/pCi)	Silo 3 CEDE without radon (mrem/g)
Actinium-227	**925**	1.29E+00	1,194
Actinium-228	406	1.25E-04	<0.1
Bismuth-210	3,480	1.96E-04	1
Bismuth-212	367	1.91E-05	<0.1
Bismuth-214	3,870	6.22E-06	<0.1
Francium-223	13	6.22E-06	<0.1
Protactinium-231	**627**	8.58E-01	538
Protactinium-234	2	8.14E-07	<0.1
Protactinium-234m	1,778	8.14E-07	<0.1
Lead-210	**3,480**	1.36E-02	47
Lead-211	925	8.70E-06	<0.1
Lead-212	367	1.69E-04	<0.1
Lead-214	3,870	7.81E-06	<0.1
Polonium-210	3,480	8.58E-03	30
Radium-223	925	7.84E-03	7
Radium-224	**367**	3.16E-03	1
Radium-226	**3,870**	1.4E-01	542
Radium-228	**406**	4.77E-03	2
Thorium-227	925	1.62E-02	15
Thorium-228	**747**	3.42E-01	255
Thorium-230	**60,200**	2.62E-01	15,748
Thorium-231	117	8.77E-07	<0.1
Thorium-232	**842**	1.15E+00	969
Thorium-234	1,780	3.50E-05	<0.1
Uranium-234	**1,730**	1.32E-01	229
Uranium-235/236	**117**	1.23E-01	14
Uranium-238	**1,780**	1.18E-01	211
TOTAL			**19,805**

a. Actual measured values are in bold type.
b. Federal Guidance Report No. 11 [Ref. 10] for all values except Ra226. The Ra226 DCF is from CAP88-PC, Version 2.1, class Y.

G-3.0 ACCIDENT ANALYSES

The accidents analyzed include (1) hose rupture during pneumatic transfer, (2) silo wall containment failure while cutting an opening, (3) spill of material due to conveyor failure, (4) breach of a full soft-sided package, (5) failure of the collectors in the pneumatic retrieval system, and (6) spill contents of a cargo container. These accident scenarios and analysis results are described in the following sections.

Safety analysis presented here relies on DOE-HDBK-3010-94 for established values for airborne release fractions (ARF) for free-fall spills and respirable fractions (RF). The dose consequences presented in this Appendix were derived applying the factors presented in DOE-HDBK-3010-94 for solid powders [Ref. 2]. The factors presented in this reference guide were developed in part on empirical testing of the properties of the oxides of the elements aluminum, silicon, titanium and uranium. The materials present in Silo 3, largely oxides or sulfates of magnesium, iron, sodium, calcium and aluminum, were byproducts of the extraction of uranium from milled ores and ore concentrates. Following extraction, the residues were subsequently calcined in the presence of lime and pneumatically conveyed into the silo. As a result of the waste generating process, concern was expressed by some internal reviewers that the application of the factors recommended in DOE-HDBK-3010-94 may not be appropriately representative of the characteristics of the waste. The most significant difference is the unusually low bulk density of the Silo 3 waste, e.g., about half the bulk density of sand. At this lower bulk density it is possible that a larger airborne release fraction could occur as the result of an accident than indicated in the experiments reported in the HDBK.

To ensure that the dose consequences derived through the hazard calculations for the selected accident scenarios were appropriately representative of the waste materials involved and present reasonable bounding values, the total dose was calculated twice. First, by applying the experimentally determined factors reported in DOE-HBDK-3010-94, and then separately by utilizing the bounding values given in the HDBK. The bounding values used were an airborne release fraction of 0.01 for free-fall spills of powder, and a respirable fraction of 0.36. The results of these analyses are a simple linear increase by a factor of 6 (2E-3x0.3 versus 0.01x0.36); however, the increase was not significant enough to result in any change to the Hazard Categorization conclusions. These results are presented in each affected EBA Table (EBA 1, 3, 4, 5 and 6) under "Solids Results", along with those derived utilizing the factors presented in DOE-HBDK-3010-94. For EBA 2 the results of using a bounding RF of 0.36 (ARF was not questioned) is presented in TABLE G.3.2 along with those derived utilizing the factors presented in DOE-HBDK-3010-94.

G-3.1 EBA-1: Hose Rupture During Pneumatic Retrieval

In this accident scenario, the Pneumatic Retrieval System has been in use for two hours when the hose carrying Silo 3 material to the Pneumatic Retrieval Collector, DCL-10-5002, breaks at a location inside the fabric structure. A conservative assumption is used that the fabric structure is open to the environment. When the line breaks, the motive force for material removal is stopped. However, all the material in the line between the vacuum

wand and the pneumatic retrieval collector is assumed to be released to the atmosphere inside the fabric structure. All solids and radon present are assumed to be released to the environment.

The vacuum line is 150-ft long by 6 in. in diameter. With an airflow of 1,200 cfm and a solids removal rate of 10 yd^3 per hour, and based on a bulk density of 50 lb/ft^3, the air will have a density of 0.188 lb/ft^3:

$$50\ lb/ft^3 \times 10\ yd^3/hr \times min/1200\ ft^3 \times 27ft3/yd3 \times hr/60min = 0.188\ lb/ft^3$$

Therefore, 5.56 lb will be released from the 150-ft length.

The initial radon release is conservatively assumed as 0.0475 Ci, which is the headspace inventory based on 300,000 pCi/L and a headspace volume of 5,600 ft^3. In addition to the initial radon release, radon will be released from the remaining silo material at a rate of 6.26×10^6 pCi/minute over the next 24 hours. The emission rate is based on the headspace inventory, where emission rate equals decay rate. The decay rate is 0.0475 Ci x 0.693/5500 min.

The solids dispersion is modeled using the Gaussian plume model for ground-level releases. The radon dispersion is modeled using the Fernald radon model [Ref. 6]. The receptors are assumed to be within the airborne solids plume for 1 hour. The receptors are assumed to be in the initial radon release plume for 1 hour and in the residual flux radon plume for 24 hours. **TABLE G.3-1** summarizes the scenario results; the spreadsheets are provided in ATTACHMENT 1.

TABLE G.3-1: HOSE RUPTURE DURING TRANSFER SCENARIO RESULTS

Receptor Distance	Solids Results			Radon Results for Initial Release		Radon Results for Flux		Total[1] CEDE (mrem)	Total[2] CEDE (mrem)
	X/Q	Dose[1] (mrem)	Dose[2] (mrem)	Conc. (pCi/L)	Dose (mrem)	Conc. (pCi/L)	Dose (mrem)		
30 m (HC-3)	1.77E-2	0.176	1.06	291	24	2.1	4	28	29
100 m (HC-2)	1.05E-3	0.01	0.06	60	5	0.4	0.07	5	5
350 m (MOI)	9.0E-4	0.009	0.054	12	1	0.1	0.01	1	1

1 Based on ARF of 2E-3, RF of 0.3 from DOE-HDBK-3010-94. See SECTION G-3.0 for explanation.
2 Based on ARF of 0.01, RF of 0.36, bounding. See SECTION G-3.0 for explanation.

G-3.2 EBA-2: Silo Wall Containment Failure

In this accident scenario, the Pneumatic Retrieval System has been used to remove enough Silo 3 material to allow removal of a portion of the silo wall. The wall section removal allows the use of a mechanical excavator. An historic calculation performed by Parsons determined that during a seismic event, the higher stressed lower portion of the walls would crack at approximately 5 to 10 ft above floor level [Ref. 13]. Continued seismic shaking would propagate the crack sufficiently for the dome to fall downward, allowing some solid material to spill out from the full silo. For the EBA-2 scenario, either during the cutting operation or during excavation, an unanticipated relief of stress in the silo wall occurs adjacent to the concrete cut, a crack propagates, and the dome collapses inward impacting the remaining material. PCN2

The solids release for EBA-2 is estimated in a similar manner to the Parsons-analyzed seismic event. For the EBA-2 scenario, the material has been removed in the vicinity of the wall cut before performing the wall cut operation; therefore, the silo material volume is less for this accident. It is assumed that 25 percent of the original silo material volume has been removed before the collapse. The configuration of the remaining silo material is such that the angle of repose from the floor area at the wall opening to the high solids level at the center of the silo is less than 45 degrees. Material release at the time of collapse would result from material falling toward the wall opening. The Silo 3 solid metal oxides will not slough more than 45 degrees, as documented in WSRC-TR-2000-00523, *Characterization of Fernald Silo 3 Wastes* [Ref. 14]. Therefore, the material spilling out of the collapsed region would be minimal and it is conservatively assumed that 1 percent of the silo material volume, at the time of collapse, spills outside the silo and into either the excavator area or fabric structure, depending upon the nature of the failure.

The solids release is 5,100 yd^3 x 0.75 x 0.01, which equals 38.3 yd^3 (1,033 ft^3). The initial radon release is conservatively assumed as 0.0356 Ci, which assumes that no silo ventilation was in operation. In addition to the initial radon release, radon would be released from the remaining silo material at a rate of 4.7 x 10^6 pCi/minute over the next 24 hours. These values are 75% of the values obtained with the original material volume.

The solids dispersion is modeled using the Gaussian plume model for ground-level releases. The radon dispersion is modeled with the Fernald radon model. **TABLE G.3-2** summarizes the scenario results; the spreadsheets are provided in ATTACHMENT 2 of APPENDIX G. PCN2

TABLE G.3-2: SILO WALL FAILURE SCENARIO RESULTS

Receptor Distance	Solids Results			Radon Results for Initial Release		Radon Results for Flux		Total[1] CEDE (mrem)	Total[2] CEDE (mrem)
	X/Q	Dose[1] (mrem)	Dose[2] (mrem)	Conc. (pCi/L)	Dose (mrem)	Conc. (pCi/L)	Dose (mrem)		
30 m (HC-3)	1.77E-2	273	983	217	18	1.6	3	294	1004
100 m (HC-2)	1.05E-3	16	58	45	4	0.4	0.1	20	62
350 m (MOI)	9.0E-4	14	50	9	1	0.1	<0.1	15	51

Chemicals	Concentration				ERPG-1 (mg/m^3)	ERPG-2 (mg/m^3)	ERPG-3 (mg/m^3)
	On-site [1] (mg/m^3)	On-site [2] (mg/m^3)	Off-site [1] (mg/m^3)	Off-site [2] (mg/m^3)			
Arsenic trioxide	6.62E-02	2.38E-01	6.56E-03	2.36E-02	0.03	1.4	5
Cadmium oxide	2.31E-03	8.32E-03	2.29E-04	8.24E-04	0.03	0.05	12.5
Mercuric oxide	1.11E-02	4.00E-02	1.10E-03	3.96E-03	0.025	0.1	10
Thallium sulfate	1.42E-03	5.11E-03	1.40E-04	5.04E-03	0.3	2	15
Vanadium pentoxide	1.16E-01	4.18E-01	1.15E-02	4.14E-02	0.15	0.5	35

1 Based on ARF of 1E-3, RF of 0.1 from DOE-HDBK-3010-94. See SECTION G-3.0 for explanation.
2 Based on RF of 0.36, bounding. See SECTION G-3.0 for explanation.

Of the chemical constituents in the waste, five exceed the threshold planning quantity (TPQ) values in 40 CFR 355 [Ref. 15]. After further evaluation of these five compounds, none exceed the criteria for a "low" chemical hazard classification based on Emergency Response Planning Guide (ERPG) values. The criteria for "low" chemical hazard on-site is less than ERPG-3 and off-site is less than ERPG-2.

G-3.3 EBA-3: Spill Of Material From Conveyor Failure

In this accident scenario, there is a total break in conveyor containment while removing material with the excavator at the intersection of the inclined conveyor and the transfer conveyor. The conveyed material is released directly into the interior of the process building packaging area for 15 minutes before action is taken to stop the conveyor. The transfer rate for the conveyor is 10 yd^3 per hour; therefore, 2.5 yd^3 or 3,375 lb of material is released. The solids that become airborne are released to the ventilation system. It is conservatively assumed that the filter system fails to remove the material and all materials are passed through the ventilation system and released from the 125-ft stack.

Radon present in the spilled material void spaces and radon generated over the next 24 hours is released to the ventilation system. The 2.5 yd^3 spilled material contains 0.0059 Ci Ra^{226}. Assuming 35 percent of the radon generated emanates to the void spaces, the spill will result in a release of 2.07 x 10^{-3} Ci instantaneously. The radon emanation from the remaining solids will be 260,000 pCi/min over the next 24 hours.

The solids dispersion is modeled using the Gaussian plume model for stack releases, with stability class G and wind speed of 0.5 m/second. The radon release is significantly lower than that released in EBA-1; therefore, the radon dose is negligible. **TABLE G.3-3** summarizes the scenario results; the spreadsheets are provided in ATTACHMENT 3.

TABLE G.3-3: SPILL OF MATERIAL FROM CONVEYOR SCENARIO RESULTS

Receptor Distance	Solids Result			Total [1] CEDE (mrem)	Total [2] CEDE (mrem)
	X/Q	Dose [1] (mrem)	Dose [2] (mrem)		
30 m (HC-3)	2.75E-2	167	1002	167	1002
100 m (HC-2)	7.8E-3	47.4	284	47	284
350 m (MOI)	2.24E-3	13.6	81.6	14	82

1 Based on ARF of 2E-3, RF of 0.3 from DOE-HDBK-3010-94. See SECTION G-3.0 for explanation.
2 Based on ARF of 0.01, RF of 0.36, bounding. See SECTION G-3.0 for explanation.

G-3.4 EBA-4: Breach Of Full Package

In this accident scenario, a bridge crane or forklift is assumed to be transferring a full soft-sided package. The package is either not sealed, or gets caught on a sharp edge and is ripped open. The material in the soft-sided container spills out and lands in a pile on the floor.

The cargo container bay is effectively open to the environment so that what little radon is present and the airborne solids leak from the room. It is assumed that the package volume spilled to the ground is 96 ft^3, having a bulk density of 56.3 lb/ft^3 for the treated material, for a total spill of 5,405 lb. Assuming untreated material has a density of 50 lb/ft^3, the silo 3 material comprises 89 percent of the total treated material mass. Therefore, the mass of silo 3 material released is 4810 lb (2.18 x 10^6 g).

Radon present in the spilled material void spaces and radon generated over the next 24 hours is released to the ventilation system. The 96 ft^3 of spilled material contains 0.0084 Ci Ra^{226}. Assuming 35 percent of the radon generated emanates to the void spaces, the spill will result in a release of 2.94 x10^{-3} Ci instantaneously. The radon emanation from the remaining solids will be 370,400 pCi/min over the next 24 hours.

The solids dispersion is modeled using the Gaussian plume model for ground-level releases. The radon release is significantly lower than that released in EBA-1; therefore, the radon dose is negligible. The same accident could be postulated for the ISA, with identical

consequences (but less likely because bags meet DOT requirements (are sealed) before transfer fo the ISA. The same scenario with more than one bag, although extremely unlikely, would have consequences that increase linearly (i.e. two bags would double the consequence). **TABLE G.3-4** summarizes the results; the spreadsheets are provided in ATTACHMENT **4**.

TABLE G.3-4: BREACH OF A FULL PACKAGE SCENARIO RESULTS

Receptor Distance	Solids Result			Total [1] CEDE (mrem)	Total [2] CEDE (mrem)
	X/Q	Dose [1] (mrem)	Dose [2] (mrem)		
30 m (HC-3)	1.77E-2	152	912	152	912
100 m (HC-2)	1.05E-3	9.1	54.6	9	55
350 m (MOI)	9.0E-4	7.8	46.8	8	47

1 Based on ARF of 2E-3, RF of 0.3 from DOE-HDBK-3010-94. See SECTION G-3.0 for explanation.
2 Based on ARF of 0.01, RF of 0.36, bounding. See SECTION G-3.0 for explanation.

G-3.5 EBA-5: Failure Of Collectors In Pneumatic Retrieval System

Ordinarily, the material collected by the Pneumatic Retrieval System is removed from the airstream using several unit operations in series. First is the Pneumatic Retrieval Collector consisting of a bag-house. The collector is followed by a cartridge filter and a filter housing, which contains a high-efficiency particulate air (HEPA) filter, two graded prefilters, and an ultra-low-penetrating air filter.

During extraction, an abrupt pressure change causes a blowout of the downstream filters and disables the Pneumatic Retrieval Collector. The extracted material flows directly to the stack and is emitted to the atmosphere. The material and associated radon are released at the design flow-rate of 1,200 ft^3/minute of air containing 0.188 lb solids/ft^3.

50 lb/ft^3 x 10 yd^3/hr x min/1200 ft^3 x 27ft3/yd3 x hr/60min = 0.188 lb/ft^3

The accident is unmitigated for 15 minutes, resulting in a release of 3,384 lbs of solids.

The initial radon release is conservatively assumed as 0.0475 Ci, which is the headspace inventory based on 300,000 pCi/L and a volume of 5,600 ft^3. In addition to the initial radon release, radon will be released from the remaining silo material at a rate of 6.26 x 10^6 pCi/minute over the next 15 minutes. The total radon release is 0.048 Ci.

The solids dispersion is modeled using the Gaussian plume model for stack releases, with stability class G and wind speed of 0.5 m/second. The radon dispersion is modeled with the Fernald radon model. **TABLE G.3-5** summarizes the scenario results; the spreadsheets are provided in ATTACHMENT 5.

TABLE G.3-5: FAILURE OF PRS COLLECTORS SCENARIO RESULTS

Receptor Distance	Solids Results			Radon Results for Initial Release		Total [1] CEDE (mrem)	Total [2] CEDE (mrem)
	X/Q	Dose [1] (mrem)	Dose [2] (mrem)	Concentration (pCi/L)	Dose (mrem)		
30 m (HC-3)	2.75E-2	167	1002	294	24	191	1026
100 m (HC-2)	7.8E-3	47.5	285	61	5	53	290
350 m (MOI)	2.24E-3	13.6	81.6	12	1	15	83

1 Based on ARF of 2E-3, RF of 0.3 from DOE-HDBK-3010-94. See SECTION G-3.0 for explanation.
2 ased on ARF of 0.01, RF of 0.36, bounding. See SECTION G-3.0 for explanation.

G-4.0 CONCLUSIONS

Analysis of five accident scenarios produced the radiological dose estimates for workers, co-located workers, and off-site populations that are presented in **TABLES G.4-1** and **G.4-2**. Workers are defined as any personnel performing work on the Silo 3 project within the boundaries of the facility (30 m receptor). Co-located workers are defined as other workers located within the boundaries of the FCP site, but not performing work on the Silos 3 project (100 m receptor). The off-site population is defined as all non-workers who reside or are otherwise located outside the FCP site boundaries. The nearest off-site point for the MOI is approximately 350 m west of the silos. **TABLE G.4-1** provides calculated internal dose estimates for individuals located at 30, 100, and 350 m from the point of the release. The offsite dose estimate is compared to the 25 rem EG established by DOE-STD-3009-94 [Ref. 1].

TABLES G.4-1 and G.4-2 provide calculated internal dose estimates for individuals located at 30, 100, and 350 m from the point of the release. The offsite dose estimate is compared to the 25 rem EG established by DOE-STD-3009-94. TABLE G.4.1 presents the dose estimates using ARF and RF values from DOE-HDBK-3010-94 [Ref. 2], and **TABLE G.4-2** presents the dose estimates using the more bounding ARF and RF values. As expected, the bounding ARF and RF factors resulted in higher dose consequences; however both sets of dose estimates support the conclusion that the final hazard categorization of Radiological is appropriate, and no safety-class structures, systems, and components (SSC) or technical safety requirements are needed.

Of the chemicals present, five exceed the TPQ values in 40 CFR 355. Further evaluation of these five compounds determined that none exceed the on-site and off-site criteria for a "low" chemical hazard classification based on ERPG values.

TABLE G.4-1: DOSE FOR COMPARISON TO DOSE TO EMERGENCY GUIDELINE

Event	Radiological Dose CEDE at various distances (mrem)		
	30 m	100 m	350 m*
EBA-1	28	5	1
EBA-2	294	20	15
EBA-3	167	47	14
EBA-4	152	9	8
EBA-5	191	53	15

* Nearest off-site location is 350 m, which is the MOI. DOE-STD-3009-94 Public EG is 25 rem.

TABLE G.4-2: DOSE FOR COMPARISON TO EMERGENCY GUIDELINE USING CONSERVATIVE ASSUMPTIONS

Event	Radiological Dose CEDE at various distances (mrem)		
	30 m[a]	100 m[a]	350 m[b]
EBA-1	29	5	1
EBA-2	1004	62	51
EBA-3	1002	284	82
EBA-4	912	55	47
EBA-5	1026	290	83

[a] ARF = 0.01 and RF = 0.36 for free fall spill of powders
[b] Nearest off-site location is 350 m, which is the MOI. DOE-STD-3009-94 Public EG is 25 rem.

The conclusion that can be drawn from the analyses is that none of the accident scenarios analyzed yield consequences that would require "safety-class" controls as DOE-STD-3009-94, since the off-site EGs are not challenged.

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ATTACHMENT 1
EBA-1 SPREADSHEETS

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Accident Dose Calculations for Silo 3 Project - Solids Ground Release

References:

Dose conversion factors for inhalation are from Table 2.1, EPA-520/1-88-020 (Federal Guidance Report 11).
The DCF lung clearance class was selected for oxides.
The values for ARF and RF from DOE-HDBK-3010
Atmospheric stability D: Ref. DOE-STD-1027-92, Attachment 1, pages A-6 and A-7, for hazard categorization.

Dose Methodology:

DOSE = Q * X/Q * BR * DCF * t

where:

BR =	3.33E-04 m^3/s	Breathing Rate (a constant)
DCF =	rem/Ci	Dose Conversion Factor (varies)
t =	exposure time	
Q =	Airborne Source Term	

Q = MAR * DR * LPF * ARF * RF

where:

MAR =	material at risk of release	
DR =	1	damage ratio
LPF =	1	leak path factor
ARF*RF=		airborne release fraction x respirable fraction

X/Q Methodology:

A Gaussian dispersion model is used to determine the dispersion loss between the release and receptor.
The methodology allows a comparison of the effects of plume meander and wake effects. (Ref. NRC Reg Guide 1.145)

Equation 1 X/Q = 1/(U *(pi * sig-y * sig-z +(A/2)))
Equation 2 X/Q = 1/(U * (3 * pi * sig-y * sig-z))
Equation 3 X/Q = 1/(U * pi * E-y * sig-z)

The higher value from equation 1 and 2 is selected. This value is compared with the value from equation 3 and the lower value is selected as the appropriate X/Q value.

A =		cross-sectional area of structure, m^2	
d =		downwind distance to evaluation point, m	User Input
		Atmospheric stability class (D, E, F, G)	
sig-y =		lateral plume spread, m	Constant
sig-z =		vertical plume spread, m	
E-y =		lateral plume spread with wake effects, m	**Calculated**
U =		10 meter above grade wind speed, m/sec	

Dispersion Calculations:

A =	100	m^2
pi =	3.14159	
d =	30	m
	D	
sig-y =	**3.67**	m
sig-z =	**1.63**	m
E-y =	**7.35**	m
U =	1	m/s

X/Q	sec/m^3
(Eqn.1) =	1.45E-02
(Eqn.2) =	1.77E-02
(Eqn.3) =	2.65E-02
Selected EQN =	Eqn.2
X/Q =	1.77E-02

A =	100	
pi =	3.14159	
d =	3100	
	D	
sig-y =	**10.34**	
sig-z =	**4.95**	
E-y =	**12.39**	
U =	4.5	

X/Q	sec/m^3
(Eqn.1) =	1.05E-03
(Eqn.2) =	4.61E-04
(Eqn.3) =	1.15E-03
Selected EQN =	Eqn.1
X/Q =	1.05E-03

A =	100	
pi =	3.14159	
d =	350	
	F	
sig-y =	**14.04**	
sig-z =	**6.30**	
E-y =	**56.18**	
U =	1	

X/Q	sec/m^3
(Eqn.1) =	3.05E-03
(Eqn.2) =	1.20E-03
(Eqn.3) =	9.00E-04
Selected EQN =	Eqn.3
X/Q =	9.00E-04

Accident Dose Calculations for Solids Release

Dose Calculation: **EBA-1 Solids Release**

Solids Activity (pCi/cc) equals solids activity (pCi/g) x solids density
Source Term (MAR) equals solids activity (pCi/cc) x solids volume
Airborne Source Term (Q) equals the MAR x ARF x RF x DR x LPF
The DCF is listed for each isotope.
DOSE = Q * X/Q * BR * DCF * t

Dry Solid Density 0.8 g/cm^3
wt % solids 100 g solid/g slurry
Solid Density = 0.188 lb/ft^3
Release Volume = 0.8 m^3
29.5 cf

50 lb/ft3 x 10 yd3/hr x min/1200 ft3 x 27ft3/yd3 x hr/60min = 0.188 lb/ft3

ARF =	2.00E-03	
RF =	0.3	
DR =	1.0	
LPF =	1.0	
BR =	3.33E-04	m^3/s

Distance (m)	Stability Class	Wind Spd (m/s)	X/Q (s/m3)	Time (hours)
30	D	1	1.77E-02	1
100	D	4.5	1.05E-03	1
350	F	1	9.00E-04	1

Radionuclide	Solids activity pCi/g	Solids activity pCi/cc	Source Term (MAR) pCi	Airborne Source Term (Q) pCi/s	DCF (mrem/pCi)	Dose @ 30 (mrem)	Dose @ 100 (mrem)	Dose @ 350 (mrem)
Ac-227	925	2.79E+00	2.33E+06	3.88E-01	1.29E+00	1.06E-02	6.33E-04	5.40E-04
Ac-228	406	1.22E+00	1.02E+06	1.70E-01	1.25E-04	4.51E-07	2.69E-08	2.30E-08
Bi-210	3,480	1.05E+01	8.76E+06	1.46E+00	1.96E-04	6.06E-06	3.62E-07	3.09E-07
Fr-223	13	3.92E-02	3.27E+04	5.46E-03	6.22E-06	7.19E-10	4.29E-11	3.66E-11
Pa-231	627	1.89E+00	1.58E+06	2.63E-01	8.58E-01	4.78E-03	2.85E-04	2.43E-04
Pa-234	2	6.03E-03	5.04E+03	8.39E-04	8.14E-07	1.45E-11	8.63E-13	7.37E-13
Pb-210	3,480	1.05E+01	8.76E+06	1.46E+00	1.36E-02	4.21E-04	2.51E-05	2.14E-05
Po-210	3,480	1.05E+01	8.76E+06	1.46E+00	8.58E-03	2.65E-04	1.58E-05	1.35E-05
Ra-223	925	2.79E+00	2.33E+06	3.88E-01	7.84E-03	6.45E-05	3.85E-06	3.28E-06
Ra-224	367	1.11E+00	9.24E+05	1.54E-01	3.16E-03	1.03E-05	6.15E-07	5.25E-07
Ra-226	3,870	1.17E+01	9.74E+06	1.62E+00	1.40E-01	4.82E-03	2.87E-04	2.45E-04
Ra-228	406	1.22E+00	1.02E+06	1.70E-01	4.77E-03	1.72E-05	1.03E-06	8.77E-07
Th-227	925	2.79E+00	2.33E+06	3.88E-01	1.62E-02	1.33E-04	7.95E-06	6.78E-06
Th-228	747	2.25E+00	1.88E+06	3.13E-01	3.42E-01	2.27E-03	1.36E-04	1.16E-04
Th-230	60,200	1.81E+02	1.52E+08	2.53E+01	2.62E-01	1.40E-01	8.37E-03	7.14E-03
Th-231	117	3.53E-01	2.95E+05	4.91E-02	8.77E-07	9.12E-10	5.44E-11	4.64E-11
Th-232	842	2.54E+00	2.12E+06	3.53E-01	1.15E+00	8.61E-03	5.14E-04	4.38E-04
Th-234	1,780	5.36E+00	4.48E+06	7.47E-01	3.50E-05	5.54E-07	3.30E-08	2.82E-08
U-234	1,730	5.21E+00	4.36E+06	7.26E-01	1.32E-01	2.03E-03	1.21E-04	1.03E-04
U-235/236	117	3.53E-01	2.95E+05	4.91E-02	1.23E-01	1.28E-04	7.63E-06	6.51E-06
U-238	1,780	5.36E+00	4.48E+06	7.47E-01	1.18E-01	1.87E-03	1.11E-04	9.51E-05
TOTAL	8.62E+04	2.60E+02	2.17E+08	3.62E+01	4.47E+00	**1.76E-01**	**1.05E-02**	**8.97E-03**

Silo 3 Project
EBA-1 Hose Rupture - Instantaneous Radon Release

Spreadsheet EBA 1 Radon Inst

FERNALD RADON MODEL

$\ln C = A_0 + A_1\ln(Q) + A_2DW + A_3XW + A_4\ln(u_s) + A_5\ln(C_{lag})$

Where:
- C = concentration (pCi/L)
- Q = uniform emissions rate (uCi/sec)
- DW = $\ln(x^2)$ = downwind dilution term
- XW = $(y/x)^2$ = crosswind dilution term
- u_s = the mean wind speed (m/s)
- x = the downwind distance (m)
- y = the crosswind distance (m)

Coefficients	
A0	8.1624
A1	1.0158
A2	-0.6537
A3	-0.9789
A4	-1.1262
A5	N/A

Inputs			
Q =	1.32E+01	uCi/sec	0.0475 Ci/hr
Wind Speed	1.8	m/s	
y (m) =	0		
x (m)	30		
C lag =	0	pCi/L	

Result: C = 2.91E+02 pCi/L @ 30 m.

Dose Conversion:

The ^{222}Rn DAC = 3×10^{-8} uCi/mL, resulting in 5 rem, for 2000 hrs exposure (Ref. 10 CFR 835, Appendix A)
The ALI for ^{222}Rn is 4 WLM. 4 WLM = 5 rem, 1 WLM = 1.25 rem.

Approach 1

WLM =	CFT	C =	2.91E+02	pCi/L
	KN	Equilibrium Factor (F) =	1	
		Time =	1	hr
WLM =	1.71E-02	K =	17000	pCi/L /WL hr/mo
Dose =	2.14E-02 rem	N =	1	
		1 WLM =	1.25	rem

Approach 2

# of DAC =	C/DAC	C =	2.91E+02	pCi/L
# of DAC	9.71E+00	1 DAC =	3.00E-08	uCi/mL
Dose =	# DAC*F*DF*T	1 DAC =	30	pCi/L
Dose =	2.43E-02 rem	Equilibrium Factor (F) =	1	
		DAC DF =	2.5	mrem/hr
		Time =	1	hr

x (m)	Wind Speed (m/s)	C (pCi/L)	X/Q	#DAC	Ingrowth Time (min)	F equil	Time (hr)	Dose (mrem)
30	1.8	2.91E+02	2.21E-02	9.71E+00	N/A	1	1	2.43E+01
100	1.8	6.04E+01	4.57E-03	2.01E+00	N/A	1	1	5.03E+00
350	1.8	1.17E+01	8.89E-04	3.91E-01	N/A	1	1	9.78E-01

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Silo 3 Project
EBA-1 Hose Rupture - Radon Flux

Spreadsheet EBA 1 Radon Flux

FERNALD RADON MODEL

$\ln C = A_0 + A_1\ln(Q) + A_2DW + A_3XW + A_4\ln(u_s) + A_5\ln(C_{lag})$

Where:
- C = concentration (pCi/L)
- Q = uniform emissions rate (uCi/sec)
- DW = $\ln(x^2)$ = downwind dilution term
- XW = $(y/x)^2$ = crosswind dilution term
- u_s = the mean wind speed (m/s)
- x = the downwind distance (m)
- y = the crosswind distance (m)

Coefficients	
A0	8.1624
A1	1.0158
A2	-0.6537
A3	-0.9789
A4	-1.1262
A5	N/A

Inputs			
Q =	1.04E-01	uCi/sec	6.26E+06 pCi/min
Wind Speed	1.8	m/s	
y (m) =	0		
x (m)	30		
C lag =	0	pCi/L	

Result: C = 2.13E+00 pCi/L @ 30 m.

Dose Conversion:

The ^{222}Rn DAC = 3×10^{-8} uCi/mL, resulting in 5 rem, for 2000 hrs exposure (Ref. 10 CFR 835, Appendix A)
The ALI for ^{222}Rn is 4 WLM. 4 WLM = 5 rem, 1 WLM = 1.25 rem.

Approach 1

WLM =	CFT / KN	C =	2.13E+00	pCi/L
		Equilibrium Factor (F) =	1	
		Time =	1	hr
WLM =	1.26E-04	K =	17000	pCi/L /WL hr/mo
Dose =	1.57E-04 rem	N =	1	
		1 WLM =	1.25	rem

Approach 2

# of DAC =	C/DAC	C =	2.13E+00	pCi/L
# of DAC	7.11E-02	1 DAC =	3.00E-08	uCi/mL
Dose =	# DAC*F*DF*T	1 DAC =	30	pCi/L
Dose =	1.78E-04 rem	Equilibrium Factor (F) =	1	
		DAC DF =	2.5	mrem/hr
		Time =	1	hr

x (m)	Wind Speed (m/s)	C (pCi/L)	X/Q	#DAC	Ingrowth Time (min)	F equil	Time (hr)	Dose (mrem)
30	1.8	2.13E+00	2.05E-02	7.11E-02	N/A	1	24	4.27E+00
100	1.8	4.42E-01	4.24E-03	1.47E-02	N/A	1	2	7.37E-02
350	1.8	8.59E-02	8.24E-04	2.86E-03	N/A	1	2	1.43E-02

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ATTACHMENT 2
EBA-2 SPREADSHEETS

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Accident Dose Calculations for Solids Release

Dose Calculation: **EBA-2 Solids Release**

Solids Activity (pCi/cc) equals solids activity (pCi/g) x solids density
Source Term (MAR) equals solids activity (pCi/cc) x solids volume
Airborne Source Term (Q) equals the MAR x ARF x RF x DR x LPF
The DCF is listed for each isotope.
DOSE = Q * X/Q * BR * DCF * t

Dry Solid Density	0.80	g/cm^3
wt % solids	100	g solid/g slurry
Solid Density ▫	50.0	lb/ft^3
Solid Volume =	3900.8	m^3

5100 cy 137700 cf

ARF =	1.00E-03	
RF =	0.1	
DR =	0.75	
LPF ▫	0.01	
BR ▫	3.33E-04	m^3/s

Distance (m)	Stability Class	Wind Spd (m/s)	X/Q (s/m3)	Time (hours)
30	D	1	1.77E-02	1
100	D	4.5	1.05E-03	1
350	F	1	9.00E-04	1

Radionuclide	Solids activity pCi/g	Solids activity pCi/cc	Source Term (MAR) pCi	Airborne Source Term (Q) pCi/s	DCF (mrem/pCi)	Dose @ 30 (mrem)	Dose @ 100 (mrem)	Dose @ 350 (mrem)
Ac-227	925	7.41E+02	2.89E+12	6.02E+02	1.29E+00	1.65E+01	9.82E-01	8.38E-01
Ac-228	406	3.25E+02	1.27E+12	2.64E+02	1.25E-04	7.00E-04	4.18E-05	3.56E-05
Bi-210	3,480	2.79E+03	1.09E+13	2.27E+03	1.96E-04	9.40E-03	5.61E-04	4.79E-04
Fr-223	13	1.04E+01	4.06E+10	8.46E+00	6.22E-06	1.11E-06	6.65E-08	5.68E-08
Pa-231	627	5.02E+02	1.96E+12	4.08E+02	8.58E-01	7.42E+00	4.43E-01	3.78E-01
Pa-234	2	1.60E+00	6.25E+09	1.30E+00	8.14E-07	2.24E-08	1.34E-09	1.14E-09
Pb-210	3,480	2.79E+03	1.09E+13	2.27E+03	1.36E-02	6.53E-01	3.89E-02	3.32E-02
Po-210	3,480	2.79E+03	1.09E+13	2.27E+03	8.58E-03	4.12E-01	2.46E-02	2.10E-02
Ra-223	925	7.41E+02	2.89E+12	6.02E+02	7.84E-03	1.00E-01	5.97E-03	5.09E-03
Ra-224	367	2.94E+02	1.15E+12	2.39E+02	3.16E-03	1.60E-02	9.54E-04	8.14E-04
Ra-226	3,870	3.10E+03	1.21E+13	2.52E+03	1.40E-01	7.47E+00	4.46E-01	3.80E-01
Ra-228	406	3.25E+02	1.27E+12	2.64E+02	4.77E-03	2.67E-02	1.59E-03	1.36E-03
Th-227	925	7.41E+02	2.89E+12	6.02E+02	1.62E-02	2.07E-01	1.23E-02	1.05E-02
Th-228	747	5.98E+02	2.33E+12	4.86E+02	3.42E-01	3.52E+00	2.10E-01	1.79E-01
Th-230	60,200	4.82E+04	1.88E+14	3.92E+04	2.62E-01	2.17E+02	1.30E+01	1.11E+01
Th-231	117	9.37E+01	3.66E+11	7.62E+01	8.77E-07	1.41E-06	8.44E-08	7.20E-08
Th-232	842	6.74E+02	2.63E+12	5.48E+02	1.15E+00	1.34E+01	7.97E-01	6.80E-01
Th-234	1,780	1.43E+03	5.56E+12	1.16E+03	3.50E-05	8.59E-04	5.13E-05	4.37E-05
U-234	1,730	1.39E+03	5.41E+12	1.13E+03	1.32E-01	3.15E+00	1.88E-01	1.60E-01
U-235/236	117	9.37E+01	3.66E+11	7.62E+01	1.23E-01	1.98E-01	1.18E-02	1.01E-02
U-238	1,780	1.43E+03	5.56E+12	1.16E+03	1.18E-01	2.90E+00	1.73E-01	1.47E-01
TOTAL	8.62E+04	6.91E+04	2.69E+14	5.61E+04	4.47E+00	**2.73E+02**	**1.63E+01**	**1.39E+01**

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Silo 3 Project
EBA-2 Silo Failure - Instantaneous Radon Release

Spreadsheet EBA 2 Radon Inst

FERNALD RADON MODEL

$\ln C = A_0 + A_1\ln(Q) + A_2DW + A_3XW + A_4\ln(u_s) + A_5\ln(C_{lag})$

Where:
- C = concentration (pCi/L)
- Q = uniform emissions rate (uCi/sec)
- DW = $\ln(x^2)$ = downwind dilution term
- XW = $(y/x)^2$ = crosswind dilution term
- u_s = the mean wind speed (m/s)
- x = the downwind distance (m)
- y = the crosswind distance (m)

Coefficients		Inputs			
A0	8.1624	Q =	9.90E+00	uCi/sec	0.035625 Ci/hr
A1	1.0158	Wind Speed	1.8	m/s	
A2	-0.6537	y (m) =	0		
A3	-0.9789	x (m)	30		
A4	-1.1262	C lag =	0	pCi/L	
A5	N/A				

Result: C = 2.17E+02 pCi/L @ 30 m.

Dose Conversion:

The ^{222}Rn DAC = 3×10^{-8} uCi/mL, resulting in 5 rem, for 2000 hrs exposure (Ref. 10 CFR 835, Appendix A)
The ALI for ^{222}Rn is 4 WLM. 4 WLM = 5 rem, 1 WLM = 1.25 rem.

Approach 1

WLM =	CFT / KN	C =	2.17E+02	pCi/L
		Equilibrium Factor (F) =	1	
		Time =	1	hr
WLM =	1.28E-02	K =	17000	pCi/L /WL hr/mo
Dose =	1.60E-02 rem	N =	1	
		1 WLM =	1.25	rem

Approach 2

# of DAC =	C/DAC	C =	2.17E+02	pCi/L
# of DAC	7.25E+00	1 DAC =	3.00E-08	uCi/mL
Dose =	# DAC*F*DF*T	1 DAC =	30	pCi/L
Dose =	1.81E-02 rem	Equilibrium Factor (F) =	1	
		DAC DF =	2.5	mrem/hr
		Time =	1	hr

x (m)	Wind Speed (m/s)	C (pCi/L)	X/Q	#DAC	Ingrowth Time (min)	F equil	Time (hr)	Dose (mrem)
30	1.8	2.17E+02	2.20E-02	7.25E+00	N/A	1	1	1.81E+01
100	1.8	4.51E+01	4.55E-03	1.50E+00	N/A	1	1	3.75E+00
350	1.8	8.76E+00	8.85E-04	2.92E-01	N/A	1	1	7.30E-01

Silo 3 Project
EBA-2 Silo Failure - Radon Flux

Spreadsheet EBA 2 Radon Flux

FERNALD RADON MODEL

$\ln C = A_0 + A_1\ln(Q) + A_2DW + A_3XW + A_4\ln(u_s) + A_5\ln(C_{lag})$

Where:
- C = concentration (pCi/L)
- Q = uniform emissions rate (uCi/sec)
- DW = $\ln(x^2)$ = downwind dilution term
- XW = $(y/x)^2$ = crosswind dilution term
- u_s = the mean wind speed (m/s)
- x = the downwind distance (m)
- y = the crosswind distance (m)

Coefficients	
A0	8.1624
A1	1.0158
A2	-0.6537
A3	-0.9789
A4	-1.1262
A5	N/A

Inputs		
Q =	7.83E-02 uCi/sec	4.70E+06 pCi/min
Wind Speed	1.8 m/s	
y (m) =	0	
x (m)	30	
C lag =	0 pCi/L	

Result: C = 1.59E+00 pCi/L @ 30 m.

Dose Conversion:

The ^{222}Rn DAC = 3×10^{-8} uCi/mL, resulting in 5 rem, for 2000 hrs exposure (Ref. 10 CFR 835, Appendix A)
The ALI for ^{222}Rn is 4 WLM. 4 WLM = 5 rem, 1 WLM = 1.25 rem.

Approach 1

WLM =	CFT	C =	1.59E+00	pCi/L
	KN	Equilibrium Factor (F) =	1	
		Time =	1	hr
WLM =	9.38E-05	K =	17000	pCi/L /WL hr/mo
Dose =	1.17E-04 rem	N =	1	
		1 WLM =	1.25	rem

Approach 2

# of DAC =	C/DAC	C =	1.59E+00	pCi/L
# of DAC	5.32E-02	1 DAC =	3.00E-08	uCi/mL
Dose =	# DAC*F*DF*T	1 DAC =	30	pCi/L
Dose =	1.33E-04 rem	Equilibrium Factor (F) =	1	
		DAC DF =	2.5	mrem/hr
		Time =	1	hr

x (m)	Wind Speed (m/s)	C (pCi/L)	X/Q	#DAC	Ingrowth Time (min)	F equil	Time (hr)	Dose (mrem)
30	1.8	1.59E+00	2.04E-02	5.32E-02	N/A	1	24	3.19E+00
100	1.8	3.30E-01	4.22E-03	1.10E-02	N/A	1	2	5.51E-02
350	1.8	6.42E-02	8.20E-04	2.14E-03	N/A	1	2	1.07E-02

Accident Dose Calculations for Chemical Release for Silo Failure During Wall Cutting

EBA-2 Chemical Release

Dose Calculation:

The MAR is 3825 cy (75% of 5100 cy at time of wall failure during cutting)
Chemical inventory equals concentration x solids mass
Concentration = (Compound mass x ARF x RF x DR x LPF x X/Q) / t

MAR =	3825 cy
Solid Density =	50 lb/ft^3
Solid Mass =	4.4.E+06 lb
Solid Mass =	2.0.E+06 kg

ARF =	1.00E-03	
RF =	0.1	
DR =	1.0	
LPF =	0.01	

Distance (m)	Stability Class	Wind Spd (m/s)	X/Q (s/m3)	Time (hours)
100	F	1	9.08E-03	1
350	F	1	9.00E-04	1

Chemical	Concentration (mg/kg)	Chemical Inventory (mg)	Chemical Compound	Compound Mass (mg)	Concentration @ 100 (mg/m3)	Concentration @ 350 (mg/m3)
Arsenic	7.27E+03	1.70E+10	Arsenic Pentoxide	2.62E+10	6.62E-02	6.56E-03
Cadmium	3.43E+02	8.04E+08	Cadmium Oxide	9.17E+08	2.31E-03	2.29E-04
Mercury	1.74E+03	4.08E+09	Mercuric Sulfate	4.41E+09	1.11E-02	1.10E-
Thallium	1.63E+02	3.82E+08	Thallium Sulfate	5.62E+08	1.42E-03	1.40E-
Vanadium	1.09E+04	2.56E+10	Vanadium Pentoxide	4.60E+10	1.16E-01	1.15E-02

Accident Dose Calculations for Ferrous Sulfate Release

MAR =	4500 gal
Solid Density =	1.9 g/ml
Solid Mass =	3.2.E+04 kg

ARF =	5.00E-05	
RF =	0.8	
DR =	1.0	
LPF =	1.00	

Chemical	Concentration mg/kg	Chemical Inventory mg		Concentration @ 100 (mg/m3)	Concentration @ 350 (mg/m3)
Ferrous Sulfate	1.00E+06	3.24E+10		3.26E+00	3.24E-01

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ATTACHMENT 3
EBA-3 SPREADSHEETS

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Accident Dose Calculations for Silo 3 Project - Solids Stack Release

References:

DOE-STD-3009-94
EPA-520/1-88-020
DOE-HDBK-3010
US Nuclear Regulatory Commission Reg Guide 1.145
DOE-STD-1027-92, December 1992, Change notice 1, September 1997

Dose Methodology:

DOSE = Q * X/Q * BR * DCF * t

where:

BR =	3.33E-04 m^3/s	Breathing Rate (a constant)
DCF =	rem/Ci	Dose Conversion Factor (varies)
t =	exposure time	
Q =	Airborne Source Term	

Q = MAR * DR * LPF * ARF * RF

where:

MAR =	material at risk of release	
DR =	1	damage ratio
LPF =	1	leak path factor
ARF*RF=		airborne release fraction x respirable fraction

X/Q Methodology:

A Gaussian dispersion model is used to determine the dispersion loss between the release and receptor.

For fumigation conditions:

X/Q = 1/((2*pi)^0.5 *U*sig-y*h)

Where the variables are defined as follows:

pi =	3.14159	
d =		downwind distance to evaluation point, m
		Atmospheric stability class (D, E, F, G)
h =		effective stack height, m
sig-y =		lateral plume spread, m
U =		wind speed, m/sec, at the release height

Dispersion Calculations:

	User Input	Constant	Calculated
pi =	3.14159	3.14159	3.14159
d =	30	100	350
	G	G	G
h =	38.1	38.1	38.1
sig-y =	0.76	2.68	9.36
U =	0.5	0.5	0.5
X/Q (sec/m3) =	2.75E-02	7.80E-03	2.24E-03

Accident Dose Calculations for Solids Release

Dose Calculation: **EBA-3 Solids Stack Release**

Solids Activity (pCi/cc) equals solids activity (pCi/g) x solids density
Source Term (MAR) equals solids activity (pCi/cc) x solids volume
Airborne Source Term (Q) equals the MAR x ARF x RF x DR x LPF
The DCF is listed for each isotope.
DOSE = Q * X/Q * BR * DCF * t

Dry Solid Density	0.80	g/cm^3
wt % solids	100	g solid/g slurry
Solid Density =	50.0	lb/ft^3
Solid Volume =	1.9	m^3

67.5 cf

ARF =	2.00E-03	
RF =	0.3	
DR =	1.0	
LPF =	1.0	
BR =	3.33E-04	m^3/s

Distance (m)	Stability Class	Wind Spd (m/s)	X/Q (s/m3)	Time (hours)
30	G	0.5	2.75E-02	1
100	G	0.5	7.80E-03	1
350	G	0.5	2.24E-03	1

Radionuclide	Solids activity pCi/g	Solids activity pCi/cc	Source Term (MAR) pCi	Airborne Source Term (Q) pCi/s	DCF (mrem/pCi)	Dose @ 30 (mrem)	Dose @ 100 (mrem)	Dose @ 350 (mrem)
Ac-227	925	7.41E+02	1.42E+09	2.36E+02	1.29E+00	1.00E+01	2.85E+00	8.17E-01
Ac-228	406	3.25E+02	6.22E+08	1.04E+02	1.25E-04	4.27E-04	1.21E-04	3.47E-05
Bi-210	3,480	2.79E+03	5.33E+09	8.88E+02	1.96E-04	5.74E-03	1.63E-03	4.67E-04
Fr-223	13	1.04E+01	1.99E+07	3.32E+00	6.22E-06	6.80E-07	1.93E-07	5.53E-08
Pa-231	627	5.02E+02	9.60E+08	1.60E+02	8.58E-01	4.52E+00	1.28E+00	3.68E-01
Pa-234	2	1.60E+00	3.06E+06	5.11E-01	8.14E-07	1.37E-08	3.89E-09	1.11E-09
Pb-210	3,480	2.79E+03	5.33E+09	8.88E+02	1.36E-02	3.98E-01	1.13E-01	3.24E-02
Po-210	3,480	2.79E+03	5.33E+09	8.88E+02	8.58E-03	2.51E-01	7.13E-02	2.04E-02
Ra-223	925	7.41E+02	1.42E+09	2.36E+02	7.84E-03	6.10E-02	1.73E-02	4.96E-03
Ra-224	367	2.94E+02	5.62E+08	9.37E+01	3.16E-03	9.75E-03	2.77E-03	7.94E-04
Ra-226	3,870	3.10E+03	5.93E+09	9.88E+02	1.40E-01	4.56E+00	1.29E+00	3.71E-01
Ra-228	406	3.25E+02	6.22E+08	1.04E+02	4.77E-03	1.63E-02	4.63E-03	1.33E-03
Th-227	925	7.41E+02	1.42E+09	2.36E+02	1.62E-02	1.26E-01	3.58E-02	1.03E-02
Th-228	747	5.98E+02	1.14E+09	1.91E+02	3.42E-01	2.15E+00	6.10E-01	1.75E-01
Th-230	60,200	4.82E+04	9.22E+10	1.54E+04	2.62E-01	1.33E+02	3.77E+01	1.08E+01
Th-231	117	9.37E+01	1.79E+08	2.99E+01	8.77E-07	8.63E-07	2.45E-07	7.02E-08
Th-232	842	6.74E+02	1.29E+09	2.15E+02	1.15E+00	8.14E+00	2.31E+00	6.63E-01
Th-234	1,780	1.43E+03	2.73E+09	4.54E+02	3.50E-05	5.24E-04	1.49E-04	4.26E-05
U-234	1,730	1.39E+03	2.65E+09	4.42E+02	1.32E-01	1.92E+00	5.45E-01	1.56E-01
U-235/236	117	9.37E+01	1.79E+08	2.99E+01	1.23E-01	1.21E-01	3.44E-02	9.85E-03
U-238	1,780	1.43E+03	2.73E+09	4.54E+02	1.18E-01	1.77E+00	5.02E-01	1.44E-01
TOTAL	8.62E+04	6.91E+04	1.32E+11	2.20E+04	4.47E+00	**1.67E+02**	**4.74E+01**	**1.36E+01**

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ATTACHMENT 4
EBA-4 SPREADSHEETS

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Accident Dose Calculations for Solids Release

Dose Calculation: **EBA-4 Solids Release**

Solids Activity (pCi/cc) equals solids activity (pCi/g) x solids density
Source Term (MAR) equals solids activity (pCi/cc) x solids volume
Airborne Source Term (Q) equals the MAR x ARF x RF x DR x LPF
The DCF is listed for each isotope.
DOSE = Q * X/Q * BR * DCF * t

Dry Solid Density 0.80 g/cm^3
wt % solids 100 g solid/g slurry
Solid Density = 50.0 lb/ft^3
Solid Volume = 2.7 m^3 1 sacks
96 cf

ARF =	2.00E-03	
RF =	0.3	
DR =	1.0	
LPF =	1.0	
BR =	3.33E-04	m^3/s

Distance (m)	Stability Class	Wind Spd (m/s)	X/Q (s/m3)	Time (hours)
30	D	1	1.77E-02	1
100	D	4.5	1.05E-03	1
350	F	1	9.00E-04	1

Radionuclide	Solids activity pCi/g	Solids activity pCi/cc	Source Term (MAR) pCi	Airborne Source Term (Q) pCi/s	DCF (mrem/pCi)	Dose @ 30 (mrem)	Dose @ 100 (mrem)	Dose @ 350 (mrem)
Ac-227	925	7.41E+02	2.01E+09	3.36E+02	1.29E+00	9.18E+00	5.48E-01	4.67E-01
Ac-228	406	3.25E+02	8.84E+08	1.47E+02	1.25E-04	3.90E-04	2.33E-05	1.99E-05
Bi-210	3,480	2.79E+03	7.58E+09	1.26E+03	1.96E-04	5.25E-03	3.13E-04	2.67E-04
Fr-223	13	1.04E+01	2.83E+07	4.72E+00	6.22E-06	6.22E-07	3.71E-08	3.17E-08
Pa-231	627	5.02E+02	1.37E+09	2.28E+02	8.58E-01	4.14E+00	2.47E-01	2.11E-01
Pa-234	2	1.60E+00	4.36E+06	7.26E-01	8.14E-07	1.25E-08	7.47E-10	6.38E-10
Pb-210	3,480	2.79E+03	7.58E+09	1.26E+03	1.36E-02	3.64E-01	2.17E-02	1.85E-02
Po-210	3,480	2.79E+03	7.58E+09	1.26E+03	8.58E-03	2.30E-01	1.37E-02	1.17E-02
Ra-223	925	7.41E+02	2.01E+09	3.36E+02	7.84E-03	5.58E-02	3.33E-03	2.84E-03
Ra-224	367	2.94E+02	7.99E+08	1.33E+02	3.16E-03	8.92E-03	5.32E-04	4.54E-04
Ra-226	3,870	3.10E+03	8.43E+09	1.41E+03	1.40E-01	4.17E+00	2.49E-01	2.12E-01
Ra-228	406	3.25E+02	8.84E+08	1.47E+02	4.77E-03	1.49E-02	8.89E-04	7.58E-04
Th-227	925	7.41E+02	2.01E+09	3.36E+02	1.62E-02	1.15E-01	6.88E-03	5.87E-03
Th-228	747	5.98E+02	1.63E+09	2.71E+02	3.42E-01	1.96E+00	1.17E-01	1.00E-01
Th-230	60,200	4.82E+04	1.31E+11	2.19E+04	2.62E-01	1.21E+02	7.24E+00	6.18E+00
Th-231	117	9.37E+01	2.55E+08	4.25E+01	8.77E-07	7.89E-07	4.71E-08	4.02E-08
Th-232	842	6.74E+02	1.83E+09	3.06E+02	1.15E+00	7.45E+00	4.44E-01	3.79E-01
Th-234	1,780	1.43E+03	3.88E+09	6.46E+02	3.50E-05	4.79E-04	2.86E-05	2.44E-05
U-234	1,730	1.39E+03	3.77E+09	6.28E+02	1.32E-01	1.76E+00	1.05E-01	8.94E-02
U-235/236	117	9.37E+01	2.55E+08	4.25E+01	1.23E-01	1.11E-01	6.60E-03	5.64E-03
U-238	1,780	1.43E+03	3.88E+09	6.46E+02	1.18E-01	1.62E+00	9.64E-02	8.22E-02
TOTAL	8.62E+04	6.91E+04	1.88E+11	3.13E+04	4.47E+00	**1.52E+02**	**9.10E+00**	**7.76E+00**

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ATTACHMENT 5
EBA-5 SPREADSHEETS

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Accident Dose Calculations for Solids Release

Dose Calculation: **EBA-5 Solids Stack Release**

Solids Activity (pCi/cc) equals solids activity (pCi/g) x solids density
Source Term (MAR) equals solids activity (pCi/cc) x solids volume
Airborne Source Term (Q) equals the MAR x ARF x RF x DR x LPF
The DCF is listed for each isotope.
DOSE = Q * X/Q * BR * DCF * t

Solid Density = 0.188 lb/ft^3
Release Volume = 509.9 m^3
18000 cf

ARF =	2.00E-03	
RF =	0.3	
DR =	1.0	
LPF =	1.0	
BR =	3.33E-04	m^3/s

Distance (m)	Stability Class	Wind Spd (m/s)	X/Q (s/m3)	Time (hours)
30	G	0.5	2.75E-02	1
100	G	0.5	7.80E-03	1
350	G	0.5	2.24E-03	1

Radionuclide	Solids activity pCi/g	Solids activity pCi/cc	Source Term (MAR) pCi	Airborne Source Term (Q) pCi/s	DCF (mrem/pCi)	Dose @ 30 (mrem)	Dose @ 100 (mrem)	Dose @ 350 (mrem)
Ac-227	925	2.79E+00	1.42E+09	2.37E+02	1.29E+00	1.01E+01	2.86E+00	8.19E-01
Ac-228	406	1.22E+00	6.24E+08	1.04E+02	1.25E-04	4.28E-04	1.22E-04	3.48E-05
Bi-210	3,480	1.05E+01	5.35E+09	8.91E+02	1.96E-04	5.75E-03	1.63E-03	4.68E-04
Fr-223	13	3.92E-02	2.00E+07	3.33E+00	6.22E-06	6.82E-07	1.94E-07	5.55E-08
Pa-231	627	1.89E+00	9.63E+08	1.61E+02	8.58E-01	4.54E+00	1.29E+00	3.69E-01
Pa-234	2	6.03E-03	3.07E+06	5.12E-01	8.14E-07	1.37E-08	3.90E-09	1.12E-09
Pb-210	3,480	1.05E+01	5.35E+09	8.91E+02	1.36E-02	3.99E-01	1.13E-01	3.25E-02
Po-210	3,480	1.05E+01	5.35E+09	8.91E+02	8.58E-03	2.52E-01	7.15E-02	2.05E-02
Ra-223	925	2.79E+00	1.42E+09	2.37E+02	7.84E-03	6.12E-02	1.74E-02	4.98E-03
Ra-224	367	1.11E+00	5.64E+08	9.40E+01	3.16E-03	9.78E-03	2.78E-03	7.96E-04
Ra-226	3,870	1.17E+01	5.95E+09	9.91E+02	1.40E-01	4.57E+00	1.30E+00	3.72E-01
Ra-228	406	1.22E+00	6.24E+08	1.04E+02	4.77E-03	1.63E-02	4.64E-03	1.33E-03
Th-227	925	2.79E+00	1.42E+09	2.37E+02	1.62E-02	1.26E-01	3.59E-02	1.03E-02
Th-228	747	2.25E+00	1.15E+09	1.91E+02	3.42E-01	2.15E+00	6.12E-01	1.75E-01
Th-230	60,200	1.81E+02	9.25E+10	1.54E+04	2.62E-01	1.33E+02	3.78E+01	1.08E+01
Th-231	117	3.53E-01	1.80E+08	3.00E+01	8.77E-07	8.65E-07	2.46E-07	7.04E-08
Th-232	842	2.54E+00	1.29E+09	2.16E+02	1.15E+00	8.17E+00	2.32E+00	6.65E-01
Th-234	1,780	5.36E+00	2.73E+09	4.56E+02	3.50E-05	5.25E-04	1.49E-04	4.28E-05
U-234	1,730	5.21E+00	2.66E+09	4.43E+02	1.32E-01	1.93E+00	5.47E-01	1.57E-01
U-235/236	117	3.53E-01	1.80E+08	3.00E+01	1.23E-01	1.21E-01	3.45E-02	9.88E-03
U-238	1,780	5.36E+00	2.73E+09	4.56E+02	1.18E-01	1.77E+00	5.03E-01	1.44E-01
TOTAL	8.62E+04	2.60E+02	1.32E+11	2.21E+04	4.47E+00	**1.67E+02**	**4.75E+01**	**1.36E+01**

Silo 3 Project
EBA-5 Collector Failure - Instantaneous Radon Release

Spreadsheet EBA 5 Radon Inst

FERNALD RADON MODEL

$\ln C = A_0 + A_1\ln(Q) + A_2DW + A_3XW + A_4\ln(u_s) + A_5\ln(C_{lag})$

Where:
- C = concentration (pCi/L)
- Q = uniform emissions rate (uCi/sec)
- DW = $\ln(x^2)$ = downwind dilution term
- XW = $(y/x)^2$ = crosswind dilution term
- u_s = the mean wind speed (m/s)
- x = the downwind distance (m)
- y = the crosswind distance (m)

Coefficients	
A0	8.1624
A1	1.0158
A2	-0.6537
A3	-0.9789
A4	-1.1262
A5	N/A

Inputs			
Q =	1.32E+01	uCi/sec	0.0475 Ci/hr
Wind Speed	1.8	m/s	
y (m) =	0		
x (m)	30		
C lag =	0	pCi/L	

Result: C = 2.91E+02 pCi/L @ 30 m.

Dose Conversion:

The ^{222}Rn DAC = 3×10^{-8} uCi/mL, resulting in 5 rem, for 2000 hrs exposure (Ref. 10 CFR 835, Appendix A)
The ALI for ^{222}Rn is 4 WLM. 4 WLM = 5 rem, 1 WLM = 1.25 rem.

Approach 1

WLM =	CFT	C =	2.91E+02	pCi/L
	KN	Equilibrium Factor (F) =	1	
		Time =	1	hr
WLM =	1.71E-02	K =	17000	pCi/L /WL hr/mo
Dose =	2.14E-02 rem	N =	1	
		1 WLM =	1.25	rem

Approach 2

# of DAC =	C/DAC	C =	2.91E+02	pCi/L
# of DAC	9.71E+00	1 DAC =	3.00E-08	uCi/mL
Dose =	# DAC*F*DF*T	1 DAC =	30	pCi/L
Dose =	2.43E-02 rem	Equilibrium Factor (F) =	1	
		DAC DF =	2.5	mrem/hr
		Time =	1	hr

x (m)	Wind Speed (m/s)	C (pCi/L)	X/Q	#DAC	Ingrowth Time (min)	F equil	Time (hr)	Dose (mrem)
30	1.8	2.91E+02	2.21E-02	9.71E+00	N/A	1	1	2.43E+01
100	1.8	6.04E+01	4.57E-03	2.01E+00	N/A	1	1	5.03E+00
350	1.8	1.17E+01	8.89E-04	3.91E-01	N/A	1	1	9.78E-01

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Appendix H

APPENDIX H
HEALTH PHYSICS PLAN

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TABLE H.3-1: Dose Rates At Various Operator Stations 12

ACRONYMS

ACL = Administrative control level
ALARA = As low as reasonably achievable
Anti-C = Anti-contamination
CAM = Continuous Air Monitor
CCTV = Closed-circuit television
CFM = Cubic feet per minute
CFR = Code of Federal Regulations
CEDE = Committed effective dose equivalent
cm^2 = Square centimeters
DAC = Derived air concentration
DOE = U.S. Department of Energy
Dpm = Disintegrations per minute
FCP = Fernald Closure Project
HEPA = High-efficiency particulate air
HPP = Health Physics Plan
µCi/mL = Microcuries per milliliter
MRS = Mechanical Retrieval System
Mrem = Millirem
PCM = Personal contamination monitor
PF = Protection factor
PPE = Personal protective equipment
PRS = Pneumatic Retrieval System
RCT = Radiological Control Technician
RD = Removal and Disposal
RDR = Radiological Deficiency Reports
RF = Radio frequency
RWP = Radiation Work Permit
SILO 3 = Silo 3 Retrieval and Disposition Project
TEDE = Total effective dose equivalent
TLD = Thermoluminescent dosimeter
ULPA = Ultra low penetrating air (filter)

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H-1.0 INTRODUCTION

This Health Physics Plan (HPP) describes the radiological controls specifically planned for the Silo 3 Retrieval and Disposition Project. It documents the radiological protection program elements and radiological hazards/controls specific to Silo 3 Operations. This HPP also meets the requirements stated in RM-0020 [Ref. 1] for an Occupational ALARA (As Low As Reasonably Achievable) Plan. The following elements are discussed in this document:

- General description of the Silo 3 Project
- Radiological hazards unique to the Silo 3 Project
- Engineering, administrative controls, and personal protective equipment (PPE) to mitigate radiological hazards
- Conduct of radiological work
- ALARA objectives

H-2.0 GENERAL DESCRIPTION OF THE SILO 3 PROJECT

A process flow diagram, **FIGURE H.2-1**, is provided to help describe the Silo 3 waste retrieval and packaging process. For a facility layout, see the 11x17 foldout, **FIGURE 1-4**, in the main body of the N-HASP.

The Silo 3 remediation process consists of two basic parts: waste retrieval and packaging. Retrieval is accomplished in two ways: pneumatic and mechanical. The pneumatic retrieval system is contained in a steel beam/metal-sided building adjacent to the silo. The mechanical retrieval system is housed in an adjacent robust concrete structure. Some material handling and packaging equipment is shared by the two systems.

Prior to pneumatically retrieving material from Silo 3, radon concentrations in the Silo 3 headspace will be reduced by venting the headspace through the Silo 3 stack. Silo 3 is enclosed in a fabric structure, which provides protection from the elements for personnel operating the pneumatic retrieval system (PRS). Initially, waste material will be removed from the top of the silo using a vacuum wand through the existing silo dome man-ways. The entrained material will be transported to a pneumatic retrieval collector. The retrieval collector will collect and separate the air-entrained waste. The air is further treated by a baghouse in series with a cartridge filter to collect any material remaining airborne. Finally, the air is treated with a high-efficiency particulate air (HEPA) and ultra-low penetrating air (ULPA) filter to reduce the amount of particulate material prior to the air being released to the atmosphere.

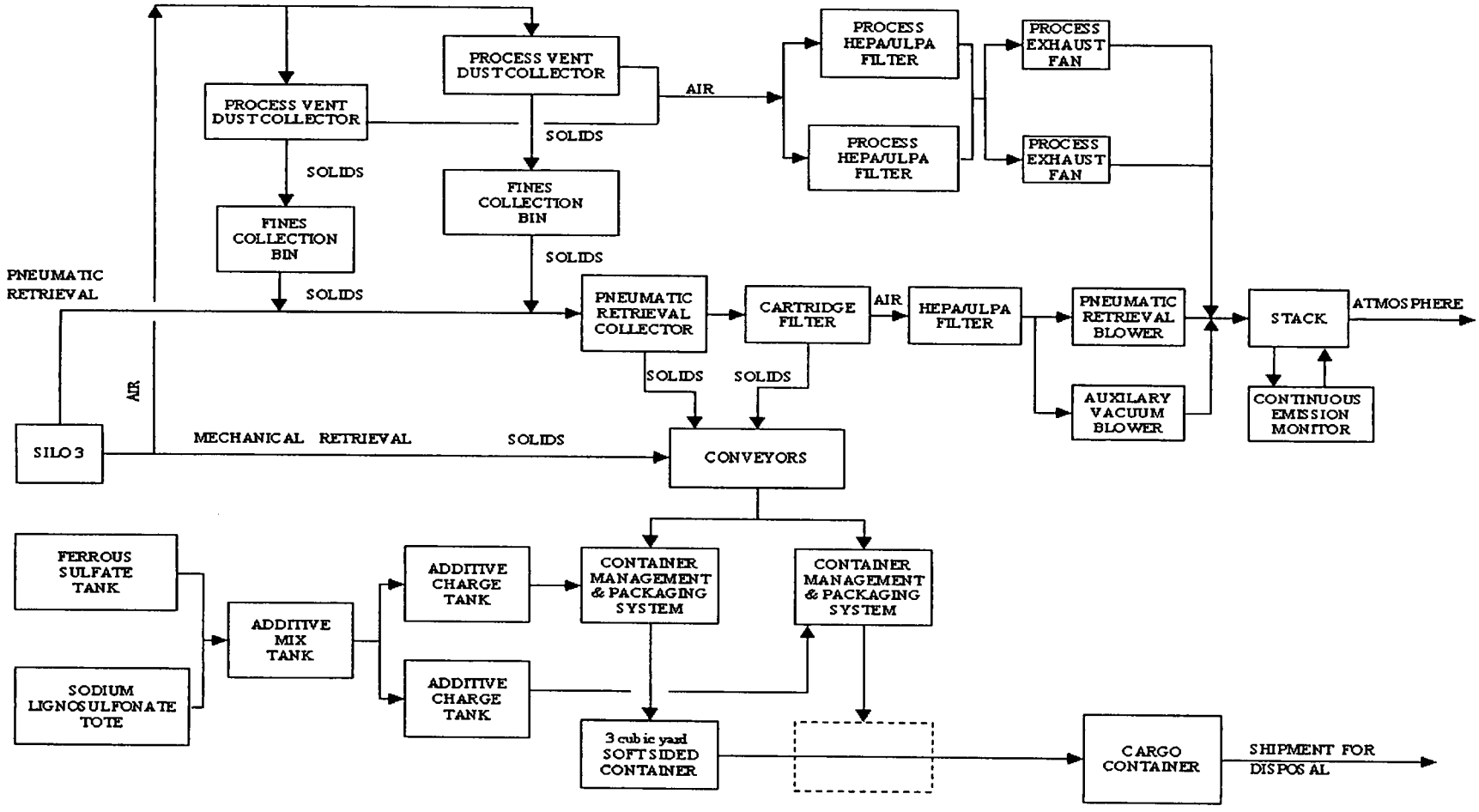
The material in the retrieval collector is sent via screw conveyors and rotary feeders to one of two packaging stations, where the waste will be dropped into a lined, soft-sided container. The polypropylene bag is a sturdy, flexible container which meets the transportation requirements for an IP-2 package. The poly-vinyl chloride (PVC) liner will be filled using a "bag-out" procedure to ensure that none of the powdered waste is released to the adjacent work area.

The Silo 3 material will be conditioned by the addition of an aqueous solution to reduce dispersibility and metals mobility. The solution of ferrous sulfate, sodium lignosulfonate, and water will be sprayed onto the material in the fill chutes of the packaging stations. Each of the two Package Loading Stands is a semi-automated system with loading spouts, loading stands, thumper tables, weighing scales, and motorized roller conveyors for transporting the filled bags away from the station. Labeled bags are transported to the Cargo Container Bay where they are transferred into cargo containers using a bridge crane.

When the PRS has removed sufficient material from the silo to expose the inside of the silo wall, the mechanical retrieval system (MRS) phase will commence to retrieve the remaining waste. An opening will be cut into the exposed wall of the silo to enable the use of a mechanical excavator. Using a remotely-operated excavator, material will be removed from the silo and placed in a below-grade bin in the Excavator Room. The material will be moved from there to the packaging stations by four conveyors. Three of the conveyors are screw-type, and one is a pocketed side-wall belt conveyor. This conveyor has a mating belt that covers the material during transfer. The last of the screw-type conveyors is common to the pneumatic retrieval system. The conveyers feed the material to the adjacent Process Building.

For both the PRS and MRS, the end product is an IP-2-approved, soft-sided container or bulk bag containing a heat-sealed PVC liner full of Silo 3 material. The packages will be surveyed as appropriate, decontaminated if necessary, and transferred to a Sea/Land container. When the shipping container is full, it will be removed and staged for final shipment off-site.

FIGURE H.2-1 - SILO 3 OPERATIONS PROCESS FLOW DIAGRAM



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H-3.0 PRIMARY RADIOLOGICAL HAZARDS FOR SILO 3 WASTE

Silo 3 contains 5,100 yd^3 of calcined by-product material from uranium ore processing. Constituent radionuclides include:

Ac-227, Ac-228, Bi-210, Bi-211, Bi-212, Bi-214, Fr-223, Pb-210, Pb-211, Pb-212, Pb-214, Po-210, Po-212, Po-214, Po-215, Po-216, Po-218, Pa-231, Pa-234, Pa-234m, Ra-223, Ra-224, Ra-226, Ra-228, Tl-207, Tl-208, Th-227, Th-228, Th-230, Th-231, Th-232, Th-234, U-234, U-235/236, U-238, Rn-219, Rn-220, and Rn-222.

More than 80 percent of the relative dose fraction from an uptake of Silo 3 material into the body would result from Th-230. Therefore, survey techniques, contamination controls, and airborne radioactivity controls will be based on those limits set for Th-230.

Silo 3 material does not exhibit a high whole-body penetrating gamma exposure hazard. However, bulk handling of the material will result in chronic exposures to low-level radiation from the waste. In terms of radiation exposure potential for the occupational worker, the major concern is an intake of Th-230. There is also a potential for internal exposure from radon daughters. As a result of these hazards, engineering controls were designed into the system to contain and confine the material, and to handle the material indirectly via specialized equipment. SECTION H-5.0 lists the engineering controls designed to help minimize the exposure potential and help maintain radiation exposures ALARA.

H-3.1 Radioisotopes of Concern

The most limiting radioisotopes for Silo 3 operations shall be determined and applied as the radioisotopes of concern for radiological control purposes. This determination was based on sampling data and calculations. The radioisotopes of concern for the Silo 3 Project are:

- Thorium-230: Contamination Control/Unrestricted Releases
- Thorium-230/Radon-222: Airborne Radioactivity Controls
- Uranium-238: Digging/Disturbing Soil

H-3.2 Potential Exposures to Contamination/Airborne Radioactivity

Contamination in the Silo 3 Project during waste removal operations is expected to be contained internally within the Silo 3 containment structure and buildings. Since Th-230 has a very low contamination limit for posting [20 disintegrations per minute (dpm)/100 square centimeters (cm^2)], the Silo 3 facility will be posted and controlled as a High Contamination and/or Contamination Area. However, the facility is designed to minimize the amount of contamination in work areas. Areas such as the Packaging Room, Cargo Bay Loading Area, Vacuum Retrieval Area, and the Remote Excavator Area are designed to implement an operating philosophy based on ALARA principles, through isolation, containment and ventilation.

Some areas and/or operations where higher levels of contamination are expected include, the Excavator Room, the Excavator Service Room, and whenever a system is breached for maintenance. Engineering and administrative controls are to be used in these areas to minimize the spread of contamination, and consequently, the generation of airborne radioactive material.

H-3.3 Potential Exposures to Radiation Exposure

TABLE H.3-1 shows the anticipated radiation dose rates for the major work areas.

TABLE H.3-1: DOSE RATES AT VARIOUS OPERATOR STATIONS

Location	Expected Dose Rate millirem (mrem)/hr
On top of dome performing pneumatic retrieval using vacuum wand	1.9
Remote Operator Station adjacent to the Excavator Room	0.4
Packaging Room	0.4
Cargo Bay Area w/ full container in area	2.0

H-4.0 ESTIMATED RADIOLOGICAL EXPOSURES

H-4.1 External Exposures

An estimate of the collective dose from the activities and the required support for Silo 3 has been prepared and is contained in ALARA Analysis, Appendix D of the N-HASP.

H-4.2 Internal Exposures

Headspace radon, as well as radon and thorium particulates generated during mechanical processing of the retrieved dry waste, will be collected in exhaust hoods, filtered, and ventilated to the atmosphere via the Silo 3 exhaust stack. Calculations of the atmospheric release and dispersion from the exhaust stack show that doses to potential off-site recipients will be negligible (see Appendix E).

It is anticipated that few project operations will be conducted in areas where the airborne concentrations may exceed 10 percent of the Derived Air Concentration (DAC). and require respiratory protection [Ref. 2]. In these cases, the selection and use of respiratory protection equipment will be designed to prevent internal exposure.

In all cases where workers are exposed to Silo 3 material, they will be required by Radiation Work Permit (RWP) to wear full PPE and respirators to prevent skin contamination and inhalation of airborne radioactive material.

Radiological Control Technicians (RCTs) will also measure radon and radioactive airborne particulate concentrations, and determine the requirements for respiratory protection for any plan to access areas. The objective of monitoring and respiratory protection is to prevent exposures to radon concentrations and airborne particulates in excess of 10 percent of their respective DACs, and to ensure that internal exposures to radon and airborne particulates are maintained ALARA.

Internal exposures are not anticipated in the Silo 3 Project. Airborne hazards may exist when maintenance is performed or if there is a system breach. In all cases, when workers breach systems and there is potential to be exposed to contamination from Silo 3 materials, they will be required (by RWP) to wear full PPE and respiratory protection. Thus, the probability of any worker uptake is very low.

Silo 3 radiological workers will participate in the Fernald Closure Project (FCP) bioassay program, as required. Adequate precautions will be taken to maintain internal exposure to workers ALARA.

Continuous Air Monitors (CAMs) are used for the routine assessment of the potential for internal personnel exposure resulting from upset conditions. Two CAMs measure the concentration of particulate alpha-emitting radionuclides to warn against the leakage of the powdery Silo 3 material from the process equipment (the primary contaminant of concern being Th-230) and a third CAM monitors radon-222 levels. CAMs are used to measure airborne concentrations for comparison with the DAC for Th-230 of 3E-12 microcuries per milliliter (μCi/mL). The CAMs are positioned inside the Packaging Area and Excavator Service Rooms. The radon CAM is positioned inside the Packaging Area next to one of the particulate CAMs.

Readings from the CAMs and the radon monitor are available locally and in the Control Point. The alpha CAMs will have alarm setpoints established at 50% of the lowest protection factor for the assigned respiratory protection. Alarm indications will be given at the instrument area and at the RCT Control Point. In the case of an alpha CAM alarm, material processing or work will be temporarily suspended in the affected area, and personnel will make a controlled exit after equipment/systems are placed in a safe configuration. Radiological Control will evaluate the condition and work will resume after the concentrations have receded below the alarm setpoints or the condition is determined to have been a result of equipment problems that have been resolved.

H-5.0 ENGINEERING AND ADMINISTRATIVE CONTROLS

H-5.1 Engineering Controls

Management is committed to reducing radiation exposures by applying the ALARA process in the design, construction, operation, maintenance, and demobilization phases of the project. Examples of engineering controls that help maintain work activities ALARA include:

- Silo Enclosure: The use of a silo enclosure protects workers from the weather, thus allowing retrieval activities to be completed in a more timely fashion.

- Vacuum Wand Management System: The use of the Vacuum Wands for waste retrieval limits personnel exposures to bulk amounts of waste by reducing exposure time and increasing the distance from the source of the exposed worker.

- Remote Excavator: The remote excavator and cameras allows the operator to be removed from the exposure source while performing waste retrieval activities. Using an automated remote excavator that is self-greasing, and has interchangeable work attachments, further removes the operator from the exposure source.

- Excavator Room Misting System: Once the excavator is in full operation, a water-misting system may be employed for one or both of the following functions:

  - Dust suppression: During mechanical retrieval, the Silo 3 contents will be disturbed. Dusting in the Excavator Room may result (the excavator will be operated in a manner to minimize dusting).

  - Stabilization of working face: As piles of Silo 3 material are created and "groomed," water misting may be used as a safe working practice to help establish a stable face.

  Water is supplied to the system from a water tank located on the excavator. Tests have shown that the Silo 3 material has a tremendous capacity to absorb moisture before it becomes deliquescent. Because the misting system will be used infrequently and the water introduced is a small fraction of the absorbent capacity of the material, it is expected that the moisture addition would have no deleterious effect on the material handling process.

- Video Cameras: Besides providing viewing for the remote excavator, cameras will also be used by the PRS operators as they remove waste via the silo man-ways. Additional cameras can be employed for remote viewing of personnel and operations to further reduce worker exposures. The use of cameras will help reduce the number of individuals needed to perform work in areas of radiological exposure and the time needed inside the project exposure areas.

Closed-circuit television (CCTV) cameras will be provided at the following locations:

- Silo 3 (selected ports)
- Excavator Room
- Excavator

- Shielding: The project has temporary shielding available (e.g., lead blankets). However, it is not anticipated that shielding will receive widespread use due to the generally low overall radiation levels that are anticipated.

- Ventilation: Silo 3 Project ventilation is designed to maintain the incoming air flow from the silo and waste packaging building negative with respect to atmospheric pressure. The silo and waste packaging buildings have 10,000 cubic-feet-per-minute (CFM) of building ventilation, which can assist in the control of airborne radioactivity in the event of leakage. Building ventilation is pulled through a HEPA filter by an exhaust fan and discharged via the 150-foot monitored stack. Both the HEPA assembly and fan are redundant to provide for continuous operation during maintenance or filter changes.

  The system has various pick-up points throughout the building to provide good air changes to eliminate or minimize the build-up of airborne radioactivity. The exhaust stack provides for dispersal of trace radon and particulates not collected elsewhere.

  There are several engineering controls used in the Silo 3 Project to help keep radiological exposures from contamination to the workers and environment ALARA:

  - Surfaces from which radioactive material can be re-suspended are minimized (e.g., scaffolding, open rafters, hanging light fixtures, cable runs).

  - Appropriate pressure differential exists between the areas of high contamination and the outside to prevent the spread of contamination.

  - Potentially-contaminated airflow is directed away from the worker's breathing zone and is designed to minimize re-suspension of contamination. Room air may be re-circulated if adequate HEPA filtration and monitoring are provided. Re-circulation from an area of higher contamination to an area of lower contamination is prohibited.

  - The capture velocity of a hood, hose, or plenum used to capture and redirect suspended contamination is equal to or greater than 150 ft/minute, as measured at the source.

  - Potentially-radioactive particulate effluent discharges are minimized by using HEPA/ULPA filtration. The discharge from ventilation systems is directed away from potential sources of contamination to prevent re-suspension.

- The facility layout includes a series of barriers enclosing various zones that are classified according to their potential level of contamination. The number of barriers depends upon the sources of contamination, the confinement efficiency of each barrier, and the number and types of penetrations. The process equipment provides primary confinement; secondary confinement is provided by the enclosure containment. The ventilation system will be designed to assist the physical barriers in maintaining zone confinement.

- Hoods and Enclosures: Hoods and enclosures minimize airborne contamination. The Excavator Room Hood is positioned near the silo wall opening to capture saw cuttings and Silo 3 dust generated during silo wall intrusion. The vacuum wand uses a containment system. The retrieval bin uses a hood to minimize generation of airborne material at the source during mechanical retrieval. The primary and secondary rotary feeders are enclosed and act as airlocks between the relatively-high vacuum of the collector and the ambient pressure of the Feed Conveyor. The Inclined Conveyor is contained within an enclosure.

- Enclosed Conveyors: Enclosed conveyors act to contain powders during material movement.

- PVC liner: An inner liner is placed inside the soft-sided container in the loading frame. This thick PVC liner delays radon diffusion and provides containment for the Silo 3 waste residues. The liner is attached to the Package Loading Stand loading spout. An inflation blower on the Package Loading Station unit is used to expand the inner liner allowing it to conform the container internal silhouette. After this step, the container is ready for filling.

- Packaging bag-out system: Upon reaching the target fill quantity the system sends a signal to stop feeding. Alarms are included to alert operations personnel when a target weight in the container is reached. A camera is included as a safety feature. After the container is filled, a de-aerator removes air and fugitive dust, and thereby, molds the inner liner to the materials. Finally, a Radio Frequency (RF) sealer heat-seals and cuts the neck of the inner liner between containment attachment devices to leave a cover over the loading spout for contamination control. This heat seal controls contamination during separation of the bag from the packaging station.

H-5.2 Administrative Controls

The following administrative controls were developed to minimize radiation exposure for the Silo 3 Project:

- Bag-out procedures for the removal of filters from ventilation systems (i.e., the stack filters)

- Access Controls/Postings/Labeling

- RWPs/Updated Radiological Surveys for:
  - Entry into any radiological area
  - Breaching any process line, tank, vessel, or enclosure containing radioactive material that may become loose or airborne during work activities
  - Any work within the Controlled Area on contaminated or potentially contaminated equipment where safety precautions are not adequately discussed in technical work documents approved by Fluor Fernald Radiological Control
  - Digging or disturbing soil in a Soil Contamination area
  - Breaking the barrier of a Fixed Contamination Area
- Area Radiation/Contamination Monitoring: As part of the FCP's Radiological Controls Program, RCTs monitor radiation levels and surface contamination. The Silo 3 Project Radiological Engineer, in conjunction with other safety professionals, determines the required PPE, thermoluminescent dosimeters (TLDs), and any other special radiological precautions. These requirements are controlled and specified on a RWP for each task.
- Area Air Monitoring: Occupational air monitoring for radionuclides will be performed per RM-0020 and SD-2083, *Air Sampling Plan for Silo 3 Waste Removal and Disposition Operations* [Ref. 3]. PCN2
- An ALARA Analysis has been completed for Preventative Maintenance Tasks (see Appendix D)
- Airborne Radioactivity Areas: If sustained average radon concentrations and airborne particulate levels exceed 10 percent of their DAC, an Airborne Radioactivity Area will be established and appropriate respiratory protection equipment will be required, as prescribed in the RWP for the area/task. Air sampling and/or radon monitoring will continue as necessary to determine the extent and duration of the Airborne Radioactivity Area. Airborne Radioactivity areas no longer exceeding 10 percent of the DAC will be down-posted.

H-6.0 CONDUCT OF RADIOLOGICAL WORK

The conduct of radiological work is managed by the Fluor Fernald RWP program. The RWP program is used to designate the specific radiological controls, precautions, surveillance, and/or instructions to personnel. Training requirements, PPE, exposure limitations, dosimeter requirements, steps to minimize the spread of contamination, steps to limit radiation exposure to adjacent personnel, and provisions for augmented monitoring and surveillance are all specified by Radiological Control on the RWP. In addition, the RWP system provides a means to trend job exposures by inclusion of an area log and dose record sheet. Team members performing radiological work are required to read, understand, sign, and abide by the requirements prescribed on the RWP.

Radiological monitoring is performed in the Silo 3 Project areas to assess changes in radiological conditions, assess release levels of radon and particulates, prevent the spread of radioactive contamination, and limit personnel exposure. Radiological monitoring for the project will be performed in the following ways: personnel contamination monitoring, area radiation and contamination monitoring, air sampling (boundary, general area, and breathing zone), and radiobioassay if necessary.

H-6.1 Radiological Work Permits

RWPs will be generated by the cognizant Radiological Engineer. Work will not begin until the appropriate RWP is in place. The RWP informs workers of area radiological conditions, work controls, PPE, and entry/exit requirements.

Workers shall be briefed by a Supervisor or RCT on the contents of each RWP under which the workers shall perform work, and the conditions of the work area. Workers shall sign the acknowledgment sheet one time (per revision to the RWP) to indicate an understanding of the RWP requirements.

Workers shall manually or electronically sign in on the RWP applicable to the work they are to perform before entering the work areas, and shall sign out upon exiting these areas.

H-6.2 Area Air Monitoring

Area air samples are collected to monitor trends of airborne radioactive particulate levels and radon working levels, and to ensure compliance with good work practices. Occupational air monitoring for radionuclides and radon will be performed per RM-0020 and SD-2083, *Air Sampling Plan for Silo 3 Waste Removal and Disposition Operations* [Ref. 3]. PCN2

The Occupational Air Monitoring Plan contains the following information:

- Likely sources of airborne radioactivity
- Engineering and administrative controls to control the airborne radioactivity
- Proposed boundary configuration
- General description of air monitoring equipment to be used
- Description of air monitoring in occupied areas adjacent to the airborne areas
- Methods of bioassay evaluation to be implemented
- Contingency to be employed if air monitoring results are above expected values

H-6.3 Internal Dosimetry

Internal radiation monitoring is required for all radiation workers potentially exposed to surface or airborne radioactive contamination that could result in 100 mrem Committed Effective Does Equivalent (CEDE) from intakes of all radionuclides from occupational sources (excluding radon, thoron, and their short-lived progeny), or if any organ or tissue dose equivalent could exceed 5 rem CEDE.

Internal dose assessments are performed as necessary to determine significant intakes of radioactive material. Internal radiation monitoring at the FCP is accomplished by performing in vitro bioassay measurements and airborne radioactivity sampling. Radiological Control defines the internal radiation monitoring program for all FCP personnel.

In circumstances where bioassay data are not available or appropriate, air sampling results may be used to estimate internal exposure. Dose assessments from exposure to radon and its decay products will generally be based on air sampling results and exposure or access times recorded on applicable RWP's.

H-6.4 Environmental Radon Monitoring

Fluor Fernald Environmental Monitoring currently maintains many continuous radon monitors both on site and at locations off site. There are several radon monitors that run continuously, 24 hours a day, 7 days a week, in the Silos Project area. Using wireless data transmission and a Local Area Network connection, data is transmitted from the monitors to individuals at various locations, including the Communications Center, so that increases in environmental radon concentrations from on-site projects are identified in a timely manner.

The continuous monitoring project is supplemented by approximately 50 alpha track-etch radon detectors around the K-65 fenceline, selected locations on site, and at several off-site locations.

H-6.5 Contamination Control

The Silo 3 facility will be posted and controlled as a Contamination Area due to the low contamination limit for Th-230 of 20 dpm/100cm^2. Due to the project engineering controls, elevated contamination levels are only expected in a few areas. The areas where the highest contamination levels are expected are: (1) in the Excavator Room; (2) in the Excavator Service Room when performing excavator maintenance; and (3) whenever a system is breached for maintenance.

An airlock/doffing area is provided for personnel when exiting the excavator service area to allow doffing of outer layers of PPE and performing personnel monitoring. This will support the effort to keep contamination/airborne radioactivity levels ALARA in the remainder of the facility. When performing a breach of a system with potential Silo 3 residues, a High Contamination Area will be set up. Controls will be put in place to

prevent the spread of contamination to the remainder of the facility. Potentially-contaminated outer layers of PPE will be doffed at the exit from High Contamination Areas. When exiting the, Contamination Area, personnel will undergo a contamination survey through use of a personal contamination monitor (PCM) located at the access control point trailer. In the case of the PCM being inoperable, whole-body frisking will be performed.

Routine cleaning of the facility will be performed as necessary to keep contamination levels ALARA, to prevent adverse effects on air sampling results, and to prevent the gradual spread of material to areas of lower contamination.

H-6.6 Airborne Radioactivity Areas

Initially, the entire Silo 3 facility will be posted as an Airborne Radioactivity Area and respiratory protection will be required until adequate documentation has been gathered to prove that the design and controls for the facility are adequate. However, the Excavator Room will likely always be an Airborne Radioactivity Area.

Particulate air sampling and radon monitoring will be conducted throughout the facility. In addition, CAMs will be used to provide early indication in the event of elevated particulate airborne radioactivity. The project-specific Occupational Air Monitoring Plan (see SECTION H-6.2) will discuss the project's occupational radiological air monitoring in detail.

H-7.0 PERSONNEL ENTRY AND EXIT PROTOCOLS

H-7.1 Entering/Exiting the Silos Project Controlled Area

The main access into the Controlled Area for the Silos Project is primarily through Trailer 92. This is the primary location for TLD storage and for bar-coding into the area. A secondary TLD storage and badge-in location is at T-28H near the project entrance.

Workers shall obtain their TLD before reaching the Controlled Area. TLDs must be worn while the worker is in the Controlled Area and must be stored on the assigned storage rack when not in the Controlled Area. TLDs shall be worn on the outside of the worker's clothing (non-PPE), facing forward, between their waist and shoulders. Visitors may be allowed to enter the Controlled Area with a properly trained and cognizant escort upon approval of Radiological Control.

Prior to entering the Controlled Area, workers shall scan their badges or manually enter their bar-code number into the access control computer, which will verify that their training and bioassay requirements are current. If the access control computer system is inoperable, training may be verified by visual inspection of the worker's qualification card.

If a worker's training or bioassay information is insufficient or out-of-date, access to the Controlled Area is denied.

Upon leaving the Controlled Area, workers shall place their TLD in the appropriate slot in the TLD storage rack (slots shall be labeled with badge numbers) and bar-code out of the area.

H-7.2 Entering the Silo 3 Project Area

The Silo 3 Project area will be controlled as a Radiological Area. The specific posting will vary as conditions change within the project area based upon the activities to be performed. Initial anticipated postings for operations of the Silo 3 Project will include: Contamination Area, Radiation Area, Airborne Radioactivity Area, and RWP Required for Entry.

Entries will be made only by trained Radiological Workers or as required by the job-specific RWPs. Most entry points will be supported by at least one FCP RCT. The Contamination Areas will be established so that the area is minimized. Provisions will be made for a step-off pad and an area for doffing contaminated PPE. Herculite, plastic, and glove bags may be used to help prevent the spread of contamination.

H-7.3 Access to a Radiological Area

Access to a Radiological Area requires the following:

- Workers shall sign the appropriate RWP for entry and obtain and don the prescribed PPE clothing and respiratory protection equipment.
- If a worker's training or bioassay is insufficient or out-of-date, their access shall be denied.
- When wearing protective clothing so that no skin is exposed (e.g., full anti-Cs and a respirator), the worker's TLD must be worn underneath the protective clothing. When protective clothing requirements allow skin to be exposed (e.g., no respirator), the TLD must be worn on the outside of the anti-Cs.
- Before entering a Radiological Area, workers shall contact an RCT for assignment of a personal air sampler and airflow testing of the powered air-purifying respirators (if worn).

H-7.4 Exiting the Silo 3 Control Point

Personnel and material monitoring is required when exiting the Silo 3 Control Point. Workers shall perform whole-body monitoring, preferably with a PCM. RCTs will collect any special monitoring equipment (e.g., breathing zone air samplers) at the control point exit.

Personnel and material monitoring is required when exiting the Silo 3 Control Point. Upon entering the control point trailer, the worker will return all assigned personal monitoring equipment, place material in a staging area for the RCT to monitor, doff PPE and place it in the appropriate receptacles, and proceed to the whole-body monitors. Whole-body monitoring should be performed with a PCM. However, whole-body alpha frisking is acceptable when PCMs are unavailable. If contamination is detected, a Silo 3 Project RCT shall be contacted for assistance and evaluation of the alarming zones. If contamination is not detected, personnel will then sign out of the RWP.

Workers must recognize, and allow additional time for, monitoring when exiting thorium Contamination Areas due to the low contamination limits and difficulties in detecting low levels of alpha contamination. If contamination in excess of the values specified for the Silo 3 Project Surface Contamination Limits is found, personnel shall stay in the area and notify a Silo 3 Project RCT.

Some work in or near the facility may require isolated areas to be up-posted to "Contamination" or "High Contamination" areas. These areas will require added controls such as additional PPE for entry, then doffing of the additional outer PPE and local exit

monitoring. If contamination is detected while trying to exit a local Contamination Area or High Contamination Area, the worker must contact a Silo 3 Project RCT for assistance. If

no contamination is detected, the worker shall proceed directly to the main Silo 3 Control Point (as specified by the RWP) to conduct a whole-body survey with a PCM.

All material exiting Th-230 Contamination Areas shall be surveyed by an RCT. Personal items, tools, lapel samplers, and other equipment may only be surveyed out of a Contamination Area by an RCT. Workers requiring items of this nature to be removed from the Contamination Area shall give the RCT notice in advance. Workers may not remove items from a Contamination Area or radiological buffer area without specific permission from Silo 3 Project Rad Control personnel.

Workers shall always leave a Contamination Area and doff anti-Cs at the appropriate control point whenever their protective clothing is compromised, when non-water-resistant anti-Cs get wet, or when workers sweat through their protective clothing.

Workers shall sign out on the RWP upon exiting through the access control point.

High Contamination Areas will be posted in the Excavator Room, the Excavator Service Room when excavator maintenance is performed, and whenever a system is breached for maintenance. The exit to the High Contamination Area will require equipment for monitoring personnel, personal items, or equipment as well as receptacles for collection of PPE doffed upon exiting the area.

H-8.0 RADIOLOGICAL LIMITS AND RESPIRATORY PROTECTION

H-8.1 Personnel/Equipment Monitoring Limits

Equipment monitoring for release out of a Contamination or Controlled Area from the Silo 3 Project must be surveyed for loose contamination and fixed plus removable contamination. The limits are < 20 dpm/100 cm^2 (alpha) removable contamination and 500 dpm/100 cm^2 (alpha) fixed plus removable contamination. For free release, the limits are < 20 dpm/100 cm^2 (alpha) removable and 100 dpm/100 cm^2 (alpha) fixed plus removable.

Personnel exiting Contamination Areas or High Contamination Areas for the Silo 3 Control Point shall be surveyed using instrumentation capable of detecting 500 dpm/100 cm^2 alpha, which is the personnel contamination monitoring threshold for Th-230.

Generally, personnel monitoring at the Silo 3 Control Point Trailer will be performed using automated whole-body monitors. However, if these monitors are not operable, out-of-service hand-held monitoring equipment will be provided.

If a personnel monitoring instrument alarms, then the worker shall notify the RCT. The RCT will investigate to determine if there is long-lived contamination on the worker's clothing or skin (e.g., radium, thorium, uranium). If this is confirmed, the RCT will proceed as prescribed by procedure for personal decontamination.

H-8.2 Airborne Radioactivity Limits

Airborne Radioactivity Areas shall be posted around locations that exceed, or are likely to exceed, the DAC values for the applicable radioisotope(s), or areas where a person could receive 12 DAC-hrs in a week without respiratory protection. Engineering and/or administrative controls shall be implemented for these areas to control the impact on personnel and other project areas. The DAC values that apply to the Silo 3 Project are:

- Th-230 effective DAC: 3×10^{-12} µCi/mL
- Rn-222 daughters: 0.33 Working-levels

The protection factors (PFs) that apply to the Silo 3 Project are:

- 1,000 for atmosphere supplying, airline, hood, continuous flow
- 1,000 for powered, air-purifying respirators
- 50 for full-face, air-purifying respirators
- 1 for no respirator or half-mask respirators

H-8.3 External Radiation Limits

Radiological administrative control levels (ACLs) will be used by the Silo 3 Project to keep exposures ALARA. RM-0020 establishes an annual facility ACL of 1,000 mrem total effective dose equivalent (TEDE) to an individual in a year.

Workers shall be restricted from working in radiologically-controlled areas if total (external and internal) exposures, in any one calendar year, nears 1,000 mrem TEDE without the prior approval of the Fluor Fernald President.

An investigation shall be initiated by Fluor Fernald when a worker reaches 80 percent of the ACL. The investigation will determine whether the worker requires limitations on work in a radiological area to ensure that the annual limit (1,000 mrem TEDE) is not exceeded.

H-9.0 RESPONSIBILITIES

H-9.1 Personnel Responsibilities

Silos Project Director: Overall responsibility to implement the requirements of this plan and corrective actions, as necessary.

Operations Manager: Ensures that operations personnel implement the requirements contained within this HPP. Interfaces with Silos Project Radiological Control Lead regarding design changes and radiological issues.

Silos Project Radiological Controls Lead: Ensures that Radiological Control personnel assigned to the Silos Project are implementing required monitoring specified in this HPP. Interfaces with the Operations Manager on radiological issues encountered during operations. Provides guidance to Project Management for corrective actions. Ensures that doses on the Silos Project are maintained ALARA.

Radiological Engineer: Reviews radiological data generated by radiological monitoring to identify trends and compare them against the limits in this HPP. Makes recommendations to the Silos Project Radiological Controls Lead and Operations Manager on monitoring program or operations changes. Notifies the Silos Project Radiological Controls Lead and Project Management if contamination and airborne radioactivity limits are exceeded. Develops RWPs required for Silo 3 Project tasks and continues to monitor Silo 3 Project tasks to detect any changes that would require RWP revisions.

Radiological Control Technician Supervisor: Interfaces daily with Silos Project Operations Supervisors regarding radiological issues. Ensures that monitoring is being conducted in accordance with this HPP. Coordinates RCT coverage to ensure that qualified RCTs are available to support operations and maintenance activities.

Operations Supervisors: Interfaces with Silos Project Radiological Control on radiological issues identified through radiological and other monitoring conducted according to this HPP.

H-9.2 Radiological Incidents and Reporting

All radiological incidents or abnormal events shall be immediately reported to the Silo 3 Project Radiological Engineer and Project Management. Further reporting will be required beyond these individuals as required by site procedures. Examples include, but are not limited to, skin or personal clothing contamination, situations where radioactive material uptake is suspected, and situations where contamination is spread from a radiological controlled area to the Controlled Area.

The Silo 3 Project Radiological Engineer will facilitate the documentation and proper notification of the event or condition, as required by site procedures, and ensure that corrective actions are taken, as necessary.

As required, Radiological Deficiency Reports (RDRs) will be written to document radiological deficiencies. Examples include, but are not limited to, poor performance of radiological control practices, violations of procedures or policies, and personnel contamination. The responsible supervisor will be responsible for correcting deficiencies and providing a written response summarizing action(s) taken and/or planned to prevent recurrences.

H-10.0 RCT RADIOLOGICAL COVERAGE REQUIREMENTS

Daily RCT duties will include:

- Job coverage
- Instrument operability checks
- Routine contamination verification surveys
- RWP briefings, acknowledgement forms, and daily sign-in sheets
- Issuance of respirators, lapel air samplers, direct-reading dosimeters, radon dosimeters, and other special dosimetry, as necessary.
- Air sample collection
- CAM alarm response and source check
- Periodic radon working-level tracking and downloading of files
- PCM alarm response
- Equipment and material monitoring for release
- Paperwork associated with all the above

Additionally, RCT coverage will be provided as deemed appropriate by the Silos Project Radiological Engineer and as prescribed on the RWP. Full RCT coverage is likely for activities involving breaching of contaminated systems. The RCT will perform frequent and timely surveys to ensure detection and characterization of contamination, if present. An RCT will periodically monitor radon working levels in the Silo 3 dome and waste packaging areas when personnel are inside. The Silo dome and waste packaging areas will be outfitted with remote cameras that can be viewed in the Control Room. The remote cameras will be used when appropriate to reduce personnel exposures.

H-11.0 PERSONAL PROTECTIVE EQUIPMENT

Initial start-up of the PRS and the packaging of Silo 3 waste will require the use of anti-C PPE and respiratory protection. After it has been confirmed that retrieval and packaging activities will not result in radioactive airborne concentrations that exceed DAC limits, the use of respiratory PPE requirements will be discontinued. Anti-contamination (anti-C) clothing will continue to be used and respiratory PPE will again be employed when airborne radioactive material concentrations are >10% DAC.

H-12.0 PERSONNEL/EQUIPMENT RADIOLOGICAL CONTAMINATION MONITORING

Personnel may be exposed to contamination during routine pneumatic retrieval of Silo 3 waste, repackaging, and maintenance activities. RCTs will perform routine monitoring for contamination to assess radiological conditions and post the areas as appropriate. When a Contamination Area is established within the Silo 3 Project, a control point will be established where anti-contamination clothing can be doffed and personnel will perform contamination monitoring. The RWP and area radiological postings will specify the exact requirements for monitoring.

All equipment and materials to be removed from Contamination Areas must be surveyed and released by an RCT.

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H-13.0 REFERENCES

1. RM-0020, *Radiological Control Requirements Manual*, Fluor Fernald

2. 10 CFR 835, *Occupational Radiation Protection*, Title 10, Code of Federal Regulations, Part 835, Appendix A, *Derived Air Concentrations*; DOE

3. SD-2083, *Air Sampling Plan for Silo 3 Waste Removal and Disposition Operations*, Fluor Fernald