Nuclear Criticality Safety Assessment of Decontaminated and Decommissioned Equipment Handling, Transit, and Storage at the Hematite Site

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Glossary of Acronyms, Abbreviations and Terms

Acronym / Abbreviation / Term	Definition
ALARA	As Low As Reasonably Achievable
CFFF	Columbia Fuel Fabrication Facility
CFR	Code of Federal Regulations
CSC	Criticality Safety Control
DCGL	Derived Concentration Guideline Levels
DCP	Double Contingency Principle
D&D	Decontaminated and Decommissioned
D&DE	Decontaminated and Decommissioned Equipment
DinD	Defense-in-Depth
Fissile Material	Material containing fissile nuclides (e.g. ^{235}U) in a quantity/concentration sufficient to require NCS controls/oversight.
g	Gram
kg	Kilogram
L	Liter
LEU	Low Enriched Uranium
LLW	Low Level Waste
mg	Milligram
NCS	Nuclear Criticality Safety
NCS Exempt Material	Material containing an insufficient quantity/concentration of fissile nuclides (e.g. ^{235}U) to require NCS controls/oversight.
SNM	Special Nuclear Material - material containing fissile nuclides (e.g. ^{235}U)
SSC	Systems Structure, or Component
U	Uranium
wt. %	Percentage by weight

1.0 INTRODUCTION

This Nuclear Criticality Safety Assessment (NCSA) is provided to support final decommissioning of the Hematite site. The operations assessed in this NCSA cover Decontaminated and Decommissioned (D&D) equipment handling, transit, and storage at the Hematite site. These activities also encompass remedial work associated with D&D equipment currently stored in shipping containers at the site. The results of this NCSA apply to existing D&D equipment in storage, and to equipment remaining within the former process buildings that will be removed during final decommissioning operations at the Hematite site.

This NCSA is organized as follows:

- **Section 1** introduces the NCSA of D&D equipment handling, transit, and storage at the Hematite site and provides an overview of relevant operations.
- **Section 2** provides the risk assessment of D&D equipment handling, transit, and storage activities outlined in Section 1.
- **Section 3** summarizes any important facility design features, equipment and procedural requirements identified in the criticality safety risk assessment provided in Section 2.
- **Section 4** details the conclusions of the NCSA of D&D equipment handling, transit, and storage at the Hematite site.

1.1 Description of the Hematite Site

The Westinghouse Hematite site, located near Festus, MO, is a former nuclear fuel cycle facility that is currently undergoing decommissioning. The Hematite site consists of approximately 228 acres, although operations at the site were confined to the "central tract" area which spans approximately 19 acres. The remaining 209 acres, which is not believed to be radiologically contaminated, is predominantly pasture or woodland.

The central tract area is bounded by State Road P to the north, the northeast site creek to the east, the union-pacific railroad tracks to the south, and the site creek/pond to the west. The central tract area currently includes former process buildings, facility administrative buildings, a documented 10CFR20.304 burial area, two evaporation ponds, a site pond, storm drains, sewage lines with a corresponding drain field, and several locations comprising contaminated limestone fill.

1.2 Hematite Site History

Throughout its history, operations at the Hematite facility included the manufacturing of uranium metal and compounds from natural and enriched uranium for use as nuclear fuel. Specifically, operations included the conversion of uranium hexafluoride (UF_6) gas of various ^{235}U enrichments to uranium oxide, uranium carbide, uranium dioxide pellets, and uranium metal. These products were manufactured for use by the federal government and government contractors and by commercial and research reactors approved by the Atomic Energy Commission (AEC). Research and Development was also conducted at the facility, as were uranium scrap recovery processes.

The Hematite facility was used for the manufacture of low-enriched (i.e., ≤ 5.0 wt.% ^{235}U), intermediate-enriched (i.e., >5 wt.% and up to 20 wt.% ^{235}U) and high-enriched (i.e., > 20 wt.% ^{235}U) materials during the period 1956 through 1974. In 1974 production of intermediate and high-enriched material was discontinued and all associated materials and equipment were removed from the facility. From 1974 to cessation of manufacturing operations in 2001, the Hematite facility produced nuclear fuel assemblies for commercial nuclear power plants. In 2001, fuel manufacturing operations were terminated and the facility license was amended to reflect a decommissioning scope. Accountable uranium inventory was removed and decontamination and decommissioning of equipment and surfaces within the process buildings was undertaken. This effort resulted in the removal of the majority of process piping and equipment from the buildings. At the conclusion of that project phase, the accessible surfaces of the remaining equipment and surfaces of the buildings were sprayed with fixative in preparation for building demolition.

1.3 Current State

This section describes the existing conditions at the Hematite site in regard to D&D equipment. The current state of the Hematite site in regard to overall site wide conditions is described in Reference 4.

1.3.1 D&D Equipment in Storage

As noted in Section 1.2, past decommissioning operations at the Hematite site resulted in the removal of the majority of process piping and equipment from the former process buildings. The removed D&D equipment/piping was containerized in SeaLand and Intermodal shipping containers and transported to the Mississauga Metals & Alloys (MM&A) facility located in Canada. However, a total of 25 shipping containers were subsequently returned to the Hematite site in 2007. An overview of these waste shipments is provided below. Full details of the waste shipments are provided in Reference 6.

1.3.1.1 Waste Shipments between the Hematite Site and the MM&A Facility

Waste shipments to the MM&A facility commenced during June 2005 and comprised a total of 55 shipping containers (Ref. 6). Upon receipt at MM&A the SeaLand and Intermodal shipping containers were initially placed into storage. Following storage, the MM&A recycling process was to empty a container and sort the waste into labeled cardboard bins, commonly called Gaylord boxes. Materials would be cut as necessary as they were sorted, to fit in the boxes. Metals were processed using shot blasting or acid bath to remove any residual uranium content. The processed metals were to be retained by MM&A. The shot and filter cake residue from the acid process was to be stored on site at MM&A for eventual disposal as directed by Hematite.

In December 2005 MM&A was requested by the Canadian Nuclear Safety Commission (CNSC) to stop processing waste. The exact reason was not determined but the major factors are likely that the CNSC had concerns with recent industrial accidents at MM&A combined with the total radioactive inventory which had been accumulated (there was no formal material control and accountability (MC&A) program in place at MM&A). Following an industrial event involving a zirconium fire in July 2006, the CNSC issued a stop work order to MM&A and established new limits for radioactive material that were considerably lower than their existing inventory.

Following the stop work order issued by the CNSC, MM&A contacted the Hematite site to request that the waste which had been shipped to date and the residue from processing be accepted back by the Hematite facility or for them to provide direction for disposal. Following audit of MM&A, the Hematite facility agreed to the return of the waste, excluding residues. The residues were retained by MM&A.

Beginning February 2007, a total of 25 shipping containers (14 SeaLand containers and 11 Intermodal containers), comprising materials originating from the Hematite site, were transported from the MM&A facility and received at the Hematite site. A total of 11 of the 25 shipping containers included containers that had been emptied at the MM&A facility and later repacked with Hematite materials.

Following receipt of the 25 shipping containers, each container was identified and weighed. Weighing of the received containers revealed discrepancies with 5 Intermodal containers and 4 "unopened" SeaLand containers, including a significant weight discrepancy for one "unopened" container. Inspection of the content of this container confirmed that the container had, in fact, been opened. Inspection also revealed the presence of an item not recognized as having originated from the Hematite site. The determination was based on two factors:

- The item itself was not recognized as a piece of equipment employed at Hematite; and
- The item was not coated with a fixative*.

Following a Root Cause Analysis (RCA) (Ref. 6) the subject item was identified to be a conical hopper originating from the Westinghouse Electric Company (WEC) fuel fabrication facility in Columbia, SC. Further investigation revealed the potential for the presence of additional non-Hematite materials in the shipping containers returned to the Hematite site.

Subsequent to the finding of discrepancies and the presence of non-Hematite materials associated with the shipping containers returned to the Hematite site, all shipping containers with identified discrepancies (either gross weight, visual inspection, or gross gamma survey measurements) were interrogated to verify that all contained materials were of Hematite origin and to confirm that the discrepancies were only the result of repackaging of the shipping containers at the MM&A facility. The interrogation identified the following non-Hematite materials:

- A conical hopper top originating from the WEC Columbia, SC facility; and
- A conical hopper bottom section originating from WEC Columbia, SC facility.

1.3.1.2 Existing Condition

The 25 shipping containers returned to the Hematite site in February 2007 were inspected on receipt and are currently staged on a concrete pad at the Hematite site. No processes or operations have been conducted on the materials associated with the 25 shipping containers following their receipt at the Hematite site, other than activities related to inspection and

* A fixative, containing a blue dye and therefore unique, had been sprayed on essentially all equipment during decommissioning at Hematite, to fix any residual radioactive contamination to the item.

identification of their content, in addition to radiological measurements.

1.3.2 Equipment Remaining within the Former Process Buildings

The Hematite Decommissioning Project (HDP) includes the demolition of six adjacent process buildings with some common walls. These were formerly used for fuel manufacturing operations. Accountable uranium inventory was removed and decontamination and decommissioning of equipment and surfaces within the process buildings was undertaken following cessation of fuel manufacturing operations in 2001. This effort resulted in the removal of the majority of process piping and equipment from the buildings. At the conclusion of that project phase, the accessible surfaces of the remaining equipment and surfaces of the buildings were sprayed with a fixative in preparation for building demolition.

1.3.2.1 Existing Condition

The current condition of the former process buildings is far removed from the conditions that existed prior to initiation of the past decommissioning work. The existing conditions are generally typified by empty buildings, with a relatively small quantity of remaining equipment consisting of mainly ventilation ducts and piping. The majority of the remaining equipment was cleaned and inspected during that project phase, and accessible surfaces sprayed with fixatives to lock-down any surface contamination.

The former process buildings are currently quiescent, with no activities being performed, although radiological characterization activities are planned prior to performing final decommissioning operations.

1.4 Overview of Operations Concerning D&D Equipment Handling, Transit, and Storage

This Section provides an overview of operations concerning D&D equipment handling, transit, and storage. This section provides only a criticality overview of operations and is not intended to provide an exhaustive or comprehensive process description.

1.4.1 Equipment in Storage

The 25 shipping containers currently staged at the Hematite site will be shipped to an off-site facility. However, some remedial work may be required prior to shipment, as described below.

Water ingress from precipitation or condensation may have resulted in some shipping containers collecting water. Prior to shipment of the existing 25 shipping containers to an off-site facility, remedial work to drain water from affected shipping containers will be necessary. This will involve installation of a berm around the access door(s) of the affected containers and raising of the opposite end of the containers to provide a slope to allow drainage of retained water into the berm. Water collected into each berm will be pumped into containers and manually transferred to Building 230 for treatment in the existing site water treatment plant. The treated water will be released in accordance with procedures.

In addition to the water draining and collection activities noted above, the content of some shipping containers may require unloading to facilitate characterization activities prior to shipment. The

unloaded materials will be re-loaded into either the same shipping container or another shipping container following completion of characterization activities.

1.4.2 Equipment Remaining within the Former Process Buildings

Future decommissioning operations that may be performed within the former process buildings include removal of some remaining equipment and piping. Once the removed equipment and piping has been decontaminated, or otherwise confirmed to contain only fixed surface contamination, the equipment and piping will be transferred to a loading area for shipment to an off-site facility. The equipment and piping may be temporarily stored (e.g., in a shipping container or building) prior to shipment.

1.5 Overview of Equipment used for D&D Equipment Handling, Transit, and Storage

No equipment is relied on for D&D equipment handling, transit, and storage operations, as relevant to this NCSA.

1.6 Scope of Assessment

The activities assessed in this NCSA encompass D&D equipment handling, transit, and storage at the Hematite site, in addition to remedial work associated with currently stored D&D equipment. The scope of D&D equipment assessed in this NCSA is limited to the following:

- Equipment, piping and components originating from the 25 shipping containers currently staged on site; and
- Equipment, piping and components remaining within the former process buildings.

In the event that any contaminated equipment, piping or components not associated with the above categories requires handling, transit or storage, approval shall first be obtained from the NCS Organization.

The following activities are specifically excluded from this assessment:

- Activities related to operations associated with decontamination of equipment, piping and components remaining in the former process buildings; and
- The transportation of D&D equipment, piping and components from the Hematite site to an off-site facility.

1.7 Methodology

1.7.1 NCSA Approach

This NCSA uses a risk-informed approach. Risk insights, gained from the findings of the risk assessment, are used to establish aspects of the design and process susceptible to faults important to nuclear criticality safety.

The risk informed approach is complemented with an As Low As Reasonably Achievable

(ALARA) assessment that is focused on identifying practicable measures that can be reasonably implemented to further reduce the risk of criticality to a level as low as is reasonably achievable. The ALARA assessment also serves to provide an additional degree of confidence that a criticality incident resulting from the activities assessed is not credible.

In summary, the approach used in this NCSA is as follows:

1) Establish the margin of safety between normal (i.e., expected) conditions and foreseen credible abnormal conditions.
2) Determine whether the inherent margin of safety is sufficient to safely accommodate the credible deviations from normal conditions, and if not, identify feature(s) of the process* that are important to ensuring criticality safety under all credible conditions.
3) Establish what additional practicable measures, if any, can reasonably be implemented to ensure that the risks from criticality are as low as is reasonably achievable.

1.7.2 Criticality Control Philosophy

The criticality control philosophy for the scope of operations addressed in this NCSA (Section 1.6) relies on the handling of only equipment, piping or components that have been decontaminated or otherwise confirmed to not contain any uranium fuel pellets, uranium fuel pellet fragments, or loose uranium powders (i.e., powders not associated with surface contamination of the equipment).

* In the selection of safety controls, preference is placed on use of engineered controls over procedural controls.

2.0 CRITICALITY SAFETY ASSESSMENT

The criticality safety assessment is organized as follows:

- **Section 2.1** describes the hazard identification technique employed in the criticality safety assessment of D&D equipment handling, transit, and storage activities at the Hematite site. This section also provides a summary of the hazard identification results.
- **Section 2.2** outlines the generic assumptions used in the criticality safety assessment.
- **Section 2.3** contains the criticality safety assessment of D&D equipment handling, transit, and storage activities under normal (i.e., expected) conditions.
- **Section 2.4** contains the criticality safety assessment of D&D equipment handling, transit, and storage activities under abnormal (i.e., unexpected) conditions.

2.1 Criticality Hazard Identification

This section outlines the technique used to identify criticality hazards associated with the D&D equipment handling, transit, and storage activities outlined in Section 1.4. A summary of the hazards identified is also provided, together with a brief description of their disposition in the NCSA.

2.1.1 Hazard Identification Method

The hazard identification technique employed in this criticality safety assessment uses a *What-if* analysis where the remediation approach and overall objectives are scrutinized and examined against postulated situations, focused on challenging criticality safety. As part of this process, the *What-if* analysis steps through the eleven (11) criticality safety controlled parameters to determine the extent of their importance to criticality safety.

The eleven (11) criticality safety controlled parameters examined include:

- Geometry
- Interaction
- Mass
- Isotopic/Enrichment
- Moderation
- Density
- Heterogeneity
- Neutron Absorbers
- Reflection
- Concentration
- Volume

The eleven (11) parameters listed above are traditionally considered in criticality safety assessments of processes at operating facilities possessing Special Nuclear Material (SNM).

Typically, the non-processed based nature of decommissioning operations limits the ability to control many parameters, resulting in the need to use bounding values for parameters in the NCSA in many instances.

2.1.2 Hazard Identification Results

A summary of the criticality hazards identified from the *What-If* analysis is presented in Table 2-1. If applicable, hazards that result in events with similar consequences and safeguards are grouped in single criticality accident event sequences. The criticality accident event sequences are provided in Section 2.4.

Table 2-1 Criticality Hazards Identified from the D&D Equipment Handling, Transit, and Storage Activities What-if Analysis

Event ID	What-if	Causes	Consequences	Accident Sequence in NCSA
Geometry				
There are no identified hazards associated with geometry. This is because the safety assessment of D&D equipment handling, transit, and storage activities establishes that subcriticality is assured by the low concentration of uranium associated with contamination of D&D equipment, without regard to its geometry.				
Mass & Concentration				
D&DE-C-01	There is loss of containment of uranium associated with D&D equipment.	• Spillage of uranium during D&D equipment transit. • Spillage of uranium from D&D equipment in storage.	Potential to accumulate a maximum safe mass of ^{235}U within a discrete location.	**Section 2.4.1**
D&DE-C-02	Fissile material in transit is misdirected to a D&D equipment storage area.	• Procedure non-compliance. • Incorrect labeling of a *Fissile Material Container* such that the container is not recognized or is misidentified as D&D equipment.	Potential to exceed a maximum safe mass of ^{235}U within a discrete location, other than an approved functional area.	**Section 2.4.2**
D&DE-C-03	Uranium is not fixed to D&D equipment.	• Procedure noncompliance (during equipment D&D operations). • Mobilization of contaminants due to physical disturbances or environmental conditions.	Potential to accumulate a maximum safe mass of ^{235}U within a discrete location.	**Section 2.4.3**

Event ID	What-if	Causes	Consequences	Accident Sequence in NCSA
D&DE-C-04	D&D equipment in storage comprises unapproved items.	• Procedure noncompliance (during equipment D&D operations). • Addition of unapproved sources during repacking of D&D equipment at the MM&A site prior to return shipment to the Hematite site.	Potential to exceed a maximum safe mass of ^{235}U within a discrete location.	**Section 2.4.4**
Interaction				
D&DE-C-05	There is neutron interaction between D&D equipment in transit or storage.	• Congregation of D&D equipment with uranium contamination.	Potential for excess neutron interaction between fissile materials associated with D&D equipment.	**Section 2.4.5**
Isotopic/Enrichment				
There are no identified hazards associated with presence of variable enrichment uranium associated with contamination of the D&D equipment. This is because the safety assessment is conservatively based on subcritical limits derived for uranium with 100 wt.% $^{235}U/U$ enrichment.				
Moderation				
There are no identified hazards associated with moderation. This is because the safety assessment of D&D equipment handling, transit, and storage activities establishes that subcriticality is assured under optimized water moderation conditions.				
Density				
There are no identified hazards associated with presence of variable density uranium. This is because the safety assessment of D&D equipment handling, transit, and storage activities is conservatively based on subcritical limits derived for uranium metal at maximum theoretical density.				
Heterogeneity				
There are no identified hazards associated with the presence of heterogeneous distributions of uranium (i.e. solid pieces of uranium or a conglomeration of uranium particulate). This is because the safety assessment of D&D equipment handling, transit, and storage activities Is conservatively based on subcritical limits derived for homogeneous uranium-H_2O mixtures (with 100 wt.% $^{235}U/U$ enrichment), for which subcritical limits are smaller than equivalent heterogeneous uranium-H_2O mixtures.				

Event ID	What-if	Causes	Consequences	Accident Sequence in NCSA
Neutron Absorbers				
There are no identified hazards associated with absence of fixed neutron absorbers because the safety assessment of D&D equipment handling, transit, and storage activities does not credit fixed neutron absorbers.				
Reflection				
There are no identified hazards associated with reflection conditions. This is because the safety assessment of D&D equipment handling, transit, and storage activities is based either on subcritical limits derived for infinite systems or idealized spherical geometry uranium-water mixtures with conservative reflection conditions.				
Volume				
There are no identified hazards associated with volume. This is because the safety assessment of D&D equipment handling, transit, and storage activities establishes that subcriticality is assured by either the low concentration or mass of uranium associated with contamination of D&D equipment, without regard to the volume it occupies.				

Source: Original

2.2 Generic Safety Case Assumptions

This section outlines the generic assumptions on which this criticality safety assessment is based.

2.2.1 Fissile Material Assumptions

The pertinent underlying assumptions of this NCSA related to the assessed D&D equipment handling, transit, and storage activities are as follows:

- This assessment does not consider fissile nuclides other than ^{235}U. Based on the history of the site and site documentation (refer to Section 1), there is no expectation that fissile nuclides other than ^{235}U could exist within the site boundary.
- Fissile material limits have been derived assuming homogeneous mixtures of ^{235}U and water (H_2O). This approach is conservative with respect to other materials containing uranium, including process wastes.
- The subcritical limits consider in this NCSA are based on an enrichment of 100%. This bounding assumption is extremely conservative, because the equipment considered in the NCSA was only used with low enrichments.

2.2.2 Operational Practice and Equipment Assumptions

The pertinent underlying assumptions of this NCSA related to the operational practice and equipment used for the D&D equipment handling, transit, and storage activities addressed are described and documented in Sections 1.4 and 1.5.

2.3 Normal Conditions

This section contains the criticality safety assessment of D&D equipment handling, transit, and storage activities under normal (i.e., expected) conditions.

Under normal conditions, D&D equipment will not contain any uranium fuel pellets, uranium fuel pellet fragments, or loose uranium powders (i.e., powders not associated with surface contamination of equipment). Furthermore, any residual uranium associated with contamination would be expected to be fixed to the associated equipment by virtue of the physical contamination of their surfaces and the fixatives applied following their decontamination.

The maximum safe fissile concentration for an infinite system comprising only ^{235}U (i.e., uranium of any enrichment) and water is 11.6 $g^{235}U/L$ (Table A-1, Ref. 4). This limit is a very conservative bound for D&D equipment due to the optimized conditions on which this limit is based compared with the inefficient conditions expected for uranium associated with the equipment. This limit is also very conservative due to the scope of this NCSE (Section 1.6), which ensures that any uranium associated with contamination of D&D equipment will have a maximum enrichment not exceeding 5.0 wt.% ^{235}U.

Under normal conditions, D&D equipment would be expected to contain very low levels of uranium contamination, orders of magnitude smaller that the infinite sea maximum subcritical limit of 11.6 $g^{235}U/L$ (Table A-1, Ref. 4). Thus, a very large margin of safety is anticipated under normal conditions.

Due to the very low concentrations of uranium anticipated to be associated with D&D equipment, any configuration or congregation of D&D equipment would be safely subcritical under normal conditions. In addition, because of the immobilized nature of the uranium that is assured by the decontamination processes, any potential re-mobilization of uranium from D&D equipment in storage (e.g., due to physical disturbances of D&D equipment, or precipitation entering shipping containers, etc.) would be very small. For this reason, the potential for accumulation of any mobilized uranium from D&D equipment in storage is expected to be very low under normal conditions. Based on the very low potential for mobilization of uranium and the very low concentrations of uranium associated with the D&D equipment, there is no potential to accumulate an unsafe mass of fissile material in a discrete location under normal conditions. This assessment is considered to bound any concerns regarding collection of uranium associated with water recovered from shipping containers.

Based on the above assessment, the operations described in Section 1.4 are safely subcritical under normal conditions.

2.4 Abnormal Conditions

This section provides an assessment of the criticality hazards identified from the *What-if* analysis conducted for the D&D equipment handling, transit, and storage activities addressed in this NCSA (Section 1.6). The *What-if* analysis (summarized in Table 2-1) identified potential criticality hazards requiring further evaluation. The postulated hazards are grouped and assessed in the following event sequences:

- Section 2.4.1: There is loss of containment of uranium associated with D&D equipment.
- Section 2.4.2: Fissile material in transit is misdirected to a D&D equipment storage area.
- Section 2.4.3: Uranium is not fixed to D&D equipment.
- Section 2.4.4: D&D equipment in storage comprises unapproved items.
- Section 2.4.5: There is neutron interaction between D&D equipment in transit or storage.

2.4.1 There is loss of containment of uranium associated with D&D equipment

2.4.1.1 Discussion

In general, loss of containment of any uranium from D&D equipment would result in dispersal of the uranium which would be expected to generally adopt a geometry characterized by lower neutron reflection, greater neutron leakage and lower fissile density. This is because the dispersed uranium would tend to form a layer of contamination at low concentration, which would be substantially un-optimized compared with the idealized conditions for which the maximum subcritical limits are based (i.e., compact spherical geometry at optimum concentration and with close fitting full water reflection). In addition, interaction with any uranium remaining affixed to the D&D equipment would be greatly reduced. All of these effects would lower the reactivity of the D&D equipment and interacting spillage, thus increasing the mass required for criticality. The only credible means of achieving a criticality due to loss of containment of uranium is if spillage of uranium occurs and accumulates over time, and if these spillages result in a localized accumulation of uranium with a sufficient fissile content (i.e., > 760 $g^{235}U$) and in the condition necessary for a low critical mass system (i.e., optimum or near optimum moderation, geometry, and reflection).

2.4.1.2 Risk Assessment

Loss of containment of uranium associated with D&D equipment in transit or storage will not, alone, lead to a criticality hazard because D&D equipment, individually, will contain very low levels of uranium contamination because of the prior decontamination processes. However, protracted spillage and accumulation of uranium from multiple D&D equipment in transit or storage could potentially result in collection of a mass with a fissile content exceeding the maximum subcritical mass limit of 760 $g^{235}U$ (Table A-1, Ref. 4). This is assessed below.

Gradual spillage of uranium from D&D equipment in transit or storage could potentially occur. However, the quantities of uranium involved would be very small because of the decontamination processes conducted on D&D equipment prior to their transit, and storage. These decontamination processes would remove any loose uranium deposits associated with the D&D equipment and would immobilize any residual contamination with the application of fixatives. To spill and accumulate a maximum subcritical mass of 760 $g^{235}U$ would, in practice, require spillage from a large quantity of D&D equipment, and particularly, for the D&D equipment to have been inadequately decontaminated prior to transit/storage. The potential to transfer and/or store equipment that has not been decontaminated, or has been inadequately decontaminated, but is classified as D&D equipment is precluded by the controls employed for decommissioning operations in the former process buildings. These upstream controls ensure that loss of containment of uranium associated with D&D equipment in transit or storage will not result in a criticality accident. To re-enforce these operational assumptions, it is important that all D&D equipment is verified to have been decontaminated and classified as *NCS Exempt Material* prior to initial transit or storage. This consists of the following verifications, however, note that this only applies prior to performing initial transit of the D&D

equipment from the decommissioning area and prior to initial storage of the D&D equipment. Any subsequent handling/transit/storage operations involving the same equipment would not be subject to these requirements:

- The D&D equipment is tagged as *NCS Exempt Material*; and
- Fixatives have been applied to the surfaces of the equipment to lock down any uranium contamination, unless their application has been exempted by Criticality Safety Controls (CSCs) or authority of the NCS Organization.

It is considered at least unlikely that equipment that has not been decontaminated, or has been inadequately decontaminated, could be transferred and/or stored as D&D equipment with a fissile mass large enough to result in a possible criticality (i.e., > 760 grams ^{235}U). This is supported by the following considerations:

- The procedures related to the verifications noted above are simple and unambiguous, and would be effective in preventing the transit or storage of unapproved items; and
- Personnel responsible for D&D equipment in transit, and storage operations are knowledgeable, trained and qualified to perform their assigned tasks, and fully recognize the importance in performing their tasks independently and according to procedure; and
- The probability of encountering equipment with significant uranium deposits is low, not least because of the past decommissioning operations undertaken at the Hematite site resulted in the removal of product material; and

It is also considered at least unlikely that a criticality accident could occur due to multiple spills of uranium during transit and/or storage of D&D equipment that has not been decontaminated for the following reasons:

- The probability of multiple spillages of uranium from D&D equipment in transit/storage would be inherently low because of the precautions exercised to ensure contamination control/radiological safety. Note that this assumption on operational practice is supported by a Defense-in-Depth (DinD) control (in Section 2.4.1.4); and
- The probability of multiple spillages in the same location would be low, because radiological controls to limit employee exposures would require clean-up of any spills upon discovery. Note that this assumption on operational practice is supported by a Defense-in-Depth (DinD) control (in Section 2.4.1.4); and
- The probability of achieving a criticality due to gradual spillage and accumulation of uranium from D&D equipment would be very low irrespective of the credible uranium mass involved. This is because the low enrichment, inefficient geometry, moderation and reflection conditions under credible spillage and accumulation scenarios would be expected to preclude potential for a criticality accident.

The existence of two independent unlikely conditions required before a criticality accident could occur ensures that this event sequence satisfies the Double Contingency Principle (DCP), because two unlikely concurrent failures would be required before a criticality accident could

be possible.

2.4.1.3 Summary of Risk Assessment

Based on the risk assessment provided above there is no potential for a criticality accident due to loss of containment of uranium associated with D&D equipment in transit/storage because:

- It is at least unlikely that CSCs could be compromised to the extent that an item not classified as *NCS Exempt Material* could be inappropriately transferred or stored as D&D equipment; and
- It is independently at least unlikely that sufficient fissile mass could be accumulated in a condition necessary for a low critical mass system (i.e., high enrichment, and optimum or near optimum moderation, geometry, and reflection).

2.4.1.4 Safety Controls

The explicit CSC and DinD controls relevant to preventing criticality due to loss of containment of uranium associated with D&D equipment are established below. No additional practicable measures for further reducing criticality risk have been identified. It is judged that the risks from criticality are as low as is reasonably achievable.

Administrative CSC 01: *Only D&D equipment SHALL be transferred to and stored in a D&D equipment storage area (i.e., a designated building or shipping container). Prior to initial transfer of D&D equipment the following criteria SHALL be satisfied:*

- *The equipment SHALL be verified to be tagged as NCS Exempt Material; and*
- *Fixatives SHALL be verified to have been applied to the surfaces of the equipment to lock down any uranium contamination, unless their application has been exempted by Criticality Safety Controls (CSCs) or authority of the NCS Organization.*

Notes:

1. *This CSC only applies prior to performing initial transit of the D&D equipment from the decommissioning area and prior to initial storage of the D&D equipment. Any subsequent handling/transit/storage operations involving the same equipment would not be subject to these requirements.*

DinD Administrative Control 01: *Any spillages of material from D&D equipment in transit should be recovered before D&D equipment transit operations are resumed. The recovered materials should be assayed or sampled to determine* ^{235}U *content. The NCS organization should be informed of the results.*

DinD Administrative Control 02: *Any spillages or suspected spillages of material from D&D equipment in storage should be recovered any time the associated storage area is emptied or otherwise cleared of equipment. The recovered materials (e.g. house-keeping sweepings) should be assayed or sampled to determine* ^{235}U *content. The NCS organization should be informed of the results.*

2.4.2 Fissile material in transit is misdirected to a D&D equipment storage area

2.4.2.1 Discussion

This event sequence addresses the implications on criticality safety due to misdirection of *fissile material* to a D&D equipment storage area. Misdirection of *fissile material* would be a concern if it resulted in a loss of mass or concentration control in a D&D equipment storage area. Under these conditions, a criticality accident would be possible.

2.4.2.2 Risk Assessment

This event sequence is bounded by the generic assessment of fissile material transit activities in Section 2.4.3 of Reference 7. Refer to Reference 7 for details.

2.4.2.3 Summary of Risk Assessment

This event sequence is assessed in Section 2.4.3 of Reference 7. Refer to Reference 7 for a summary of the risk assessment.

2.4.2.4 Safety Controls

This event sequence is assessed in Section 2.4.3 of Reference 7. Refer to Reference 7 for details of the explicit CSCs and DinD controls established for fissile material transit activities at the Hematite site.

2.4.3 Uranium is not fixed to D&D equipment

2.4.3.1 Discussion

The decontamination processes conducted as part of decommissioning operations ensure that any loose uranium deposits associated with the decommissioned equipment are removed and that any residual uranium is immobilized with the application of fixatives. In the event that D&D equipment contained loose particulates of uranium there would be a potential to spill and accumulate uranium, presenting a criticality safety concern.

2.4.3.2 Risk Assessment

The criticality safety basis for D&D equipment relies on the expectation that:

- D&D equipment will exhibit low levels of uranium due to the decontamination processes conducted during the decommissioning operations at the Hematite facility; and
- Any residual uranium will be essentially immobilized, i.e., fixed to the associated equipment by virtue of the physical contamination of their surfaces, and by the fixatives applied following decontamination.

The reliability of these operating assumptions is addressed in Section 2.4.1.2 and is re-enforced by CSCs established in Section 2.4.1.4. Based on these CSCs, D&D equipment in transit and/or storage is assured to have very low levels of uranium that is essentially fixed to the surfaces of the D&D equipment.

The potential for mobilization of the uranium associated with surface contamination of the D&D equipment in storage is considered small. While some degree of mobilization may be possible from physical disturbances (e.g. during transit) and/or from the action of water from precipitation entering some of the staged shipping containers, the quantity of uranium involved would be very small. This is supported by:

- The very low concentration and low removable rate of uranium anticipated to be associated with D&D equipment; and
- The CSCs established in Section 2.4.1.4 to re-enforce the above assumptions; and
- The low probability that physical disturbances or water ingress from precipitation could provide an effective mechanism to removing uranium contaminants that were not immobilized by prior decommissioning operations involving effective decontamination techniques.

Even if uranium associated with D&D equipment in storage was immobilized, more than 760 g^{235}U would have to preferentially migrate or entrain into a compact (i.e., small volume) efficient geometry (i.e., spherical or near spherical). This is very unlikely considering its large spatial distribution and very low average concentration, in addition to the insolubility of uranium compounds in water. Based on this and the immobilization arguments presented

above, in conjunction with the DCP compliant CSCs established in Section 2.4.1.4, there is no potential for a criticality accident due to mobilization of uranium associated with D&D equipment. Consequently, there is also no criticality safety concern associated with operations related to recovery and collection of water from shipping containers as part of the remedial operations outlined in Section 1.4.1. However, water samples will be collected and analyzed from the berms installed at the shipping container doors prior to the water being transferred to the site water treatment plant. This operational practice is reinforced by a DinD control. A further practicable measure for further reducing criticality risk concerns ceasing operations in the affected area in the event that removal of equipment for characterization purposes results in:

- the identification of any items not resembling Hematite D&D equipment (other than the known two CFFF items documented above); or
- the discovery of any uranium fuel pellets, uranium fuel pellet fragments, or loose uranium powders (i.e., powders not associated with surface contamination of equipment).

These requirements are also captured in a Defense-in-Depth (DinD) control.

2.4.3.3 Summary of Risk Assessment

Based on the risk assessment provided above there is no potential for a criticality accident due to mobilization of uranium associated with D&D equipment. This is due to the very low concentration of uranium associated with D&D equipment and the immobilized nature of the uranium contaminants. Refer to Section 2.4.1.3 for a summary of the risk assessment that demonstrates that D&D equipment is assured to have a very low concentration of uranium that is also essentially fixed to the surfaces of the D&D equipment.

2.4.3.4 Safety Controls

The CSCs relevant to ensuring that D&D equipment in transit and/or storage will exhibit very low concentrations of uranium that is essentially fixed to the surfaces of the D&D equipment are provided in Section 2.4.1.4 and are not restated here for brevity. These CSCs are equally applicable to this event sequence and will ensure that a criticality accident will not occur due to mobilization of uranium associated with D&D equipment in storage.

In addition to the abovementioned CSCs, the following DinD controls are established to ensure that the risk of criticality is as low as is reasonably achievable.

> **DinD Administrative Control 03:** *Water drained from the inside of any shipping container used for the storage of D&D equipment should be sampled for ^{235}U content prior to its recovery from the berm. In the event a sample assay result indicates a ^{235}U concentration exceeding 0.1 g^{235}U/L water recovery activities should be discontinued and the NCS organization notified.*

DinD Administrative Control 04: *Shipping container remedial work should be discontinued and the NCS organization notified in the event that any items are identified that do not resemble Hematite D&D equipment (other than the two documented CFFF items), or any uranium fuel pellets, uranium fuel pellet fragments, or loose uranium powders (i.e., powders not associated with surface contamination of equipment) are discovered.*

2.4.4 D&D equipment in storage comprises unapproved items

2.4.4.1 Discussion

A total of 25 shipping containers currently staged at the Hematite site contain D&D equipment generated from past decommissioning activities conducted within the former process buildings. The NCS basis for the safe handling and storage of this D&D equipment was provided by the governing NCS controls established for the former decommissioning activities (Ref. 1). The governing NCS controls required the removal of all fissile material holdup, other than only surface contamination, prior to declaring D&D equipment clear of hold up and exempt from NCS controls. These precautions ensured that D&D equipment would not present any credible criticality risk. However, the events described in Section 1.3.1.1 raise the potential for one or more of the 25 shipping containers currently staged at the Hematite site to contain unapproved items. In the event that any unapproved items are present and contain a significant fissile loading, a potential for an unsafe condition could exist.

2.4.4.2 Risk Assessment

Shipment of D&D equipment from the Hematite site to the MM&A facility commenced during June 2005 and comprised a total of 55 shipping containers (Ref. 6). However, a total of 25 shipping containers were returned to the Hematite site in 2007. Refer to Section 1.3.1.1 for details of the circumstances surrounding their return. A total of 11 of the 25 returned shipping containers had been emptied at the MM&A facility and later repacked with Hematite materials. Each container was identified and weighed following receipt at the Hematite site. Weighing of the received containers revealed discrepancies with some containers, including a significant weight discrepancy for one container that had been recorded as being 'unopened" at the MM&A facility. These discrepancies resulted in an investigation with each shipping container being evaluated for discrepancies between exported and returned conditions concerning gross weight, visual inspection and gross gamma survey measurement results. All shipping containers with identified discrepancies were interrogated to verify that all contained materials originated from the Hematite site, and to confirm that the discrepancies were only the result of repackaging of the shipping containers at the MM&A facility. This interrogation identified the presence of two D&D equipment items not originating from the Hematite site. These items were subsequently confirmed as:

- A conical hopper top originating from the WEC Columbia, SC facility; and
- A conical hopper bottom section originating from WEC Columbia, SC facility.

Based on the investigation and container interrogation activities described above, the potential for any of the 25 shipping containers currently staged at the Hematite site to contain additional materials with non-Hematite site origin is low. The two non-Hematite site origin items identified above were established to comprise only Low Enriched Uranium (LEU) surface contamination, similar to Hematite D&D equipment. Note that the WEC Columbia, SC Fuel Fabrication Facility (CFFF) is and has always been licensed to manufacture uranium fuel with a maximum enrichment not exceeding 5.0 wt% ^{235}U/U (Ref. 8). Thus, the presence of these

CFFF items does not erode criticality safety margin or otherwise compromise the criticality safety basis for the shipping containers.

The maximum safe fissile concentration for an infinite system comprising only ^{235}U and water is 11.6 $g^{235}U/L$ (Table A-1, Ref. 4). This limit is a very conservative bound for D&D equipment due to the optimized conditions on which this limit is based compared with the inefficient conditions expected for uranium associated with surface contamination of D&D equipment. This limit is also very conservative considering that Hematite D&D equipment in storage, as well as the two identified CFFF D&D items, are contaminated with uranium with a maximum enrichment not exceeding 5.0 wt.% ^{235}U.

To present a criticality safety concern additional unapproved items would have to be present in one or more of the 25 shipping containers and the unapproved items would have to:

- be numerous and contain uranium with a concentration exceeding 11.6 $g^{235}U/L$; or
- would have to contain uranium in a compact geometry with a mass content exceeding the maximum subcritical mass limit of 760 $g^{235}U$.

The potential for any of the 25 shipping containers to contain additional unapproved items with the minimum attributes described above is considered extremely small because:

- The shipping containers with known discrepancies have already been subject to interrogation; and
- The potential for any additional unapproved items to contain the significant uranium loading required before a criticality accident could be possible is inherently very low. This is supported by the fact that the *fissile exempt* materials received and processed at the MM&A facility would have been subject to 10 CFR 71.15 transportation criteria, which assures a low uranium concentration. Thus, any additional unapproved items would be expected to contain a similarly trivial level of uranium contamination to Hematite D&D equipment.

Based on the above considerations, a criticality accident within a shipping container comprising unapproved items, or during unloading of a shipping container comprising unapproved items, is not credible.

2.4.4.3 Summary of Risk Assessment

Based on the risk assessment provided above, a criticality accident due to the presence of unapproved items in any of the 25 shipping containers staged at the Hematite site is not credible. This determination is supported by the following considerations:

- The unapproved items would have to be significantly inconsistent with D&D equipment, in terms of uranium loading; and
- There would have to be:
  - A large number of unapproved items containing uranium with a concentration exceeding 11.6 $g^{235}U/L$; or

- The collective ^{235}U mass associated with the unapproved items would have to exceed 760 g^{235}U and be configured into a geometry that would favor a low critical mass system (i.e., assembled into a spherical or near spherical geometry); and

- The uranium would have to be suspended at optimum, or near optimum, concentration in an efficient (i.e., water) moderating medium; and
- Non fissile and non hydrogenous media would have to be absent, or at least present in small quantities, otherwise these constituents would result in dilution and parasitic neutron absorption.

2.4.4.4 Safety Controls

No CSCs have been identified in the risk assessment. However, the following DinD control (which is established in Section 2.4.3.4) ensures that the risk of criticality due to the remedial work summarized in Section 1.4.1 is as low as is reasonably achievable.

> **DinD Administrative Control 04:** *Shipping container remedial work should be discontinued and the NCS organization notified in the event that any items are identified that do not resemble Hematite D&D equipment (other than the two documented CFFF items), or any uranium fuel pellets, uranium fuel pellet fragments, or loose uranium powders (i.e., powders not associated with surface contamination of equipment) are discovered.*

2.4.5 There is neutron interaction between D&D equipment in transit or storage

2.4.5.1 Discussion

Congregation of D&D equipment in transit and/or storage raises the potential for neutron interaction between the uranium contaminants associated with the D&D equipment.

2.4.5.2 Risk Assessment

The criticality safety basis for D&D equipment relies on the expectation that:

- D&D equipment will exhibit low levels of uranium due to the decontamination processes conducted during the decommissioning operations at the Hematite facility; and
- Any residual uranium will be essentially immobilized by virtue of the physical contamination of their surfaces, and by the fixatives applied following their decontamination.

The reliability of these operating assumptions is addressed in Section 2.4.1.2 and is re-enforced by CSCs established in Section 2.4.1.4. Based on these CSCs, D&D equipment in transit and/or storage is assured to have very low levels of uranium.

The maximum safe fissile concentration for an infinite system comprising only ^{235}U and water is 11.6 g^{235}U/L (Table A-1, Ref. 4). This limit is a very conservative bound for D&D equipment due to the optimized conditions on which this limit is based compared with the inefficient conditions expected for uranium associated with surface contamination of D&D equipment. This limit is also very conservative due to the scope of this NCSE (Section 1.6), which ensures that any uranium associated with contamination of D&D equipment will have a maximum enrichment not exceeding 5.0 wt.% ^{235}U.

In practice, D&D equipment would be expected to have very low levels of uranium contamination, orders of magnitude smaller that the infinite sea maximum subcritical limit of 11.6 g^{235}U/L (Table A-1, Ref. 4). Due to the very low concentration of uranium anticipated to be associated with D&D equipment, and the CSCs established in Section 2.4.1.4 to re-enforce this operating assumption, any configuration or degree of accumulation of D&D equipment in transit and/or storage would be safely subcritical.

Note that the potential for mobilization of uranium contaminants associated with D&D equipment and their subsequent accumulation/interaction is addressed in Section 2.4.3.

2.4.5.3 Summary of Risk Assessment

Based on the risk assessment provided above there is no potential for a criticality accident due to neutron interaction between the uranium contaminants associated with the D&D equipment in transit and/or storage. This is due to the very low concentration of uranium associated with

D&D equipment. Refer to Section 2.4.1.3 for a summary of the risk assessment that demonstrates that D&D equipment is assured to have a very low concentration of uranium.

2.4.5.4 Safety Controls

The CSCs relevant to ensuring that D&D equipment in transit and/or storage will exhibit very low concentrations of uranium are provided in Section 2.4.1.4 and are not restated here for brevity. These CSCs are equally applicable to this event sequence and will ensure that a criticality accident will not occur due to neutron interaction between the uranium contaminants associated with the D&D equipment in transit and/or storage.

3.0 SUMMARY OF CRITICALITY SAFETY CONTROLS

3.1 Criticality Safety Parameters

The extent of control of each of the various criticality safety parameters introduced in Section 3.1 is summarized in Table 3-1.

Table 3-1 Criticality Safety Parameters

Nuclear Parameter	Controlled (Y/N)	Basis	Reference
Geometry	N	The safety assessment of D&D equipment handling, transit, and storage activities is conservatively based on infinite systems.	N/A
Interaction	Y	The safety assessment of D&D equipment handling, transit, and storage activities credits does not credit segregation of D&D equipment.	N/A
Mass	Y	The safety assessment of D&D equipment handling, transit, and storage activities credits upstream decontamination and decommissioning controls that ensures that D&D equipment will contain a very low uranium loading and that uranium contaminants will be essentially fixed to the surfaces of the D&D equipment.	Section 2.4.1 Section 2.4.2 Section 2.4.3 Section 2.4.4
Isotopic / Enrichment	N	The safety assessment of D&D equipment handling, transit, and storage activities is conservatively based on subcritical limits derived for uranium with 100 wt.% ^{235}U/U enrichment.	N/A
Moderation	N	The safety assessment of D&D equipment handling, transit, and storage activities does not credit moderation control.	N/A
Density	N	The safety assessment of D&D equipment handling, transit, and storage activities is conservatively based on subcritical limits derived for uranium metal at maximum theoretical density.	N/A
Heterogeneity	N	The safety assessment of D&D equipment handling, transit, and storage activities is conservatively based on subcritical limits derived for homogeneous uranium-H_2O mixtures (with 100 wt.% ^{235}U/U enrichment), for which subcritical limits are smaller than equivalent heterogeneous uranium-H_2O mixtures.	N/A

Nuclear Parameter	Controlled (Y/N)	Basis	Reference
Neutron Absorbers	N	The safety assessment of D&D equipment handling, transit, and storage activities does not credit fixed neutron absorbers.	N/A
Reflection	N	The safety assessment of D&D equipment handling, transit, and storage activities conservatively uses subcritical limits based on conservative or bounding reflection conditions.	N/A
Concentration	Y	The safety assessment of D&D equipment handling, transit, and storage activities credits upstream decontamination and decommissioning controls that ensures that D&D equipment will contain a very low uranium loading and that uranium contaminants will be essentially fixed to the surfaces of the D&D equipment.	Section 2.4.1 Section 2.4.3
Volume	Y	The safety assessment of D&D equipment handling, transit, and storage activities does not directly credit volume control.	N/A

Source: Original

3.2 Criticality Safety Controls and DinD Controls

This section provides a schedule of Systems, Structures, and Components (SSCs), CSCs, and DinD controls that have been established as important to safety in the risk assessment of D&D equipment handling, transit, and storage activities. The SSCs, CSCs, and DinD controls are numbered sequentially according to their identification in Section 2.4 of this document. Note that when SSCs, CSCs, and DinD controls captured in an NCSA are used in other documents (including other NCSAs), they are referenced using the numeric identifier from the originating NCSA and proceeded by the NCSA document number. For example, other documents citing the first CSC captured in this NCSA use the following reference; *NSA-TR-09-16 Administrative CSC 01*.

3.2.1 Systems Structures and Components

No SSCs have been identified as directly important to ensuring the criticality safety of D&D equipment handling, transit, and storage activities. Note that the explicit SSCs relevant to preventing a criticality accident in a D&D equipment storage area due to misdirection of fissile material in transit are established in Section 2.4.3 of Reference 7.

3.2.2 Criticality Safety Controls

The following CSC has been recognized as important to ensuring the criticality safety of D&D equipment handling, transit, and storage activities. Note that the explicit CSCs relevant to preventing a criticality accident in a D&D equipment storage area due to misdirection of fissile material in transit are established in Section 2.4.3 of Reference 7.

Administrative CSC 01: *Only D&D equipment SHALL be transferred to and stored in a D&D equipment storage area (i.e., a designated building or shipping container). Prior to transferring D&D equipment the following criteria SHALL be satisfied:*

- *The equipment SHALL be verified to be tagged as NCS Exempt Material; and*
- *Fixatives SHALL be verified to have been applied to the surfaces of the equipment to lock down any uranium contamination, unless their application has been exempted by Criticality Safety Controls (CSCs) or authority of the NCS Organization.*

Notes:

1. *This CSC only applies prior to performing initial transit of the D&D equipment from the decommissioning area and prior to initial storage of the D&D equipment. Any subsequent handling/transit/storage operations involving the same equipment would not be subject to these requirements.*

Based on the scope of this NCSA (Section 1.6), the following CSCs are captured:

Administrative CSC 02: *In the event that any contaminated equipment, piping or components not associated with the 25 shipping containers currently staged on site or remaining within the former process buildings requires transit or storage, approval SHALL first be obtained from the NCS Organization.*

Administrative CSC 03: *Operations involving D&D equipment SHALL NOT involve any processes that could result in mobilization of associated uranium contaminants.*

3.2.3 Defense in Depth Controls

This section lists those controls that do not directly support event sequence DCP compliance determinations, or directly support a not credible determination. These DinD controls provide additional protection to ensure that the risk of criticality is as low as is reasonably achievable.

DinD Administrative Control 01: *Any spillages of material from D&D equipment in transit should be recovered before D&D equipment transit operations are resumed. The recovered materials should be assayed or sampled to determine ^{235}U content. The NCS organization should be informed of the results.*

DinD Administrative Control 02: *Any spillages or suspected spillages of material from D&D equipment in storage should be recovered any time the associated storage area is emptied or otherwise cleared of equipment. The recovered materials (e.g. house-keeping sweepings) should be assayed or sampled to determine ^{235}U content. The NCS organization should be informed of the results.*

DinD Administrative Control 03: *Water drained from the inside of any shipping container used for the storage of D&D equipment should be sampled for ^{235}U content prior to its recovery from the berm. In the event a sample assay result indicates a ^{235}U concentration exceeding 0.1 g^{235}U/L water recovery activities should be discontinued and the NCS organization notified.*

DinD Administrative Control 04: *Shipping container remedial work should be discontinued and the NCS organization notified in the event that any items are identified that do not resemble Hematite D&D equipment (other than the two documented CFFF items), or any uranium fuel pellets, uranium fuel pellet fragments, or loose uranium powders (i.e., powders not associated with surface contamination of equipment) are discovered.*

4.0 CONCLUSION

This criticality safety assessment demonstrates that activities related to D&D equipment handling, transit, and storage activities will be safe under all normal and foreseeable abnormal conditions. The assessment has determined that there are very large margins of safety under normal (i.e., expected) conditions and that there is considerable tolerance to faults under abnormal conditions.

All event sequences identified in the *What-if* analysis and assessed in this NCSA are shown to result in no criticality consequences, or are demonstrated to not have the potential to result in a criticality accident on account of:

- There being no credible sequence of events that could result in a criticality accident; or
- Demonstration that the event sequence complies with the DCP.

It is noted that all analysis is assessed against limits based on homogeneous ^{235}U-H_2O mixtures at optimum concentration (i.e. that the assessment is not reliant on moderation control). Consequently, there are no restrictions on the use of water for operations (e.g., cleaning of a D&D equipment storage area surfaces) or for fire suppression.

5.0 REFERENCES

1. NISYS-NCS-1180-TR001, Global Nuclear Criticality Safety Evaluation for the Primary Interference Removal Project at the Westinghouse Electric Corporation Hematite Facility.

2. NSA-TR-09-13, Rev. 0, NCSA of Water Collection and Treatment Activities at the Hematite Site, B. Matthews, May 2009.

3. NSA-TR-09-08, Rev. 0, NCSA of Sub-Surface Structure Decommissioning at the Hematite Site, D. Vaughn, May 2009.

4. NSA-TR-09-15, Rev. 0, NCSA of Buried Waste Exhumation and Contaminated Soil Remediation at the Hematite Site, B. Matthews, May 2009.

5. NSA-TR-09-09, Rev. 0, NCSA of Waste Evaluation and Assay Activities at the Hematite Site, B. Matthews, May 2009.

6. CAPs-RCA-07-305-W012, Rev. 0.

7. NSA-TR-09-10, Rev. 0, NCSA of Collared Drum Staging, Buffer Storage and Transit at the Hematite Site, B. Matthews, May 2009.

8. SNM-1107, Materials License for the Westinghouse Columbia Fuel Fabrication Facility, Docket 70-1151, Amendment 5, April 10, 2009.