Attachment 3

Integrated Safety Analysis Summary for the Uranyl Nitrate Building (Revision 3)
Non-Proprietary Version

55T-04-1001

Revision 3

Integrated Safety Analysis Summary

Blended Low Enriched Uranium (BLEU) Project
Uranyl Nitrate Building (UNB)

JANUARY 2004

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Introduction and Scope

Nuclear Fuel Services, Inc. (NFS) and Framatome ANP, INC are designing and will construct and direct operation of the BLEU (Blended Low Enriched Uranium) Complex at the NFS site in Erwin, TN. The new complex and facilities therein will be licensed under the new rule 10 CFR Part 70, enacted on September 29, 2000. According to the rule, an Integrated Safety Analysis, (ISA) is to be conducted on currently operating and new facilities to assure that the performance criteria delineated in 10 CFR 70.61 are met. Industry guidance on the conduct of an ISA and content of the ISA Summary is provided in NUREG-1513 "Integrated Safety Analysis Guidance Document". Additionally, NUREG-1520, "Standard Review Plan", Chapter 3.0 Integrated Safety Analysis, outlines the NRC review and acceptance criteria for the ISA and ISA Summary.

For the BLEU Complex, compliance with the performance criteria of 10 CFR 70.61 will be demonstrated by conducting individual ISAs for each process building in the Complex. Support equipment located outside of the buildings will be evaluated where appropriate. Each of the processes in each building will be evaluated as a subset to the building ISA. This document covers the first process building in the BLEU Complex to enter operation, the Uranyl Nitrate Building (UNB). The other process buildings (and balance of plant systems) will be analyzed in a timely manner at a later date, reflecting the BLEU complex construction schedule.

A summary of the results of the ISA for the UNB is presented in this ISA Summary. Specifically included in the scope of this document is the following building and its subsystems (process systems):

Uranyl Nitrate Building [redacted]
a) BLEU UN Receipt
b) BLEU UN Storage
c) Natural UN storage and download

This summary encompasses all of the processes handling Special Nuclear Material (SNM) and any associated equipment and/or off-stream processes that could be impacted by or intermingled with SNM. As specified in 10 CFR 70.64 'Requirements for new facilities or new processes at existing facilities', the ISA considers initiating events resulting from natural phenomena to the extent that such phenomena are considered credible for the plant site.

The scope of the ISA does not include initiating events caused by sabotage, acts of war or meteorite impacts.

1.0 General Site Description

Citations in this section are from the NFS 1996 Environmental Report and the 2001 Supplemental Environmental Report for Licensing Actions to Support the Blended Low-Enriched Uranium Project at Nuclear Fuel Services.

The BLEU Complex is located in the City of Erwin, in Unicoi County, which is in the northeast portion of the State of Tennessee. The complex is on NFS owned property which is approximately 65 acres of land in a long, narrow mountain valley oriented in the southwest-to-

northeast direction. The valley is bounded on both sides by the Appalachian mountains. The site elevation ranges approximately 1638 to 1680 feet above sea level, and the surrounding mountains have a maximum elevation of 2,480 feet above sea level.

The BLEU Complex property boundary and the Controlled Area of the site are shown in Figure 1. The Controlled Area encompasses the UNB, which encloses the tanker load and unload areas. The Controlled Area is surrounded by an access control fence line patrolled by security guards.

The closest BLEU Complex property boundary is approximately 160 feet from the UNB exhaust stack and approximately 82 feet from the UNB. The closest residence is approximately 400 feet from the site boundary. Appendix C provides the NFS plant , BLEU Complex and Studsvik Processing Facility Layout. Appendix D provides a 360 degree 1 mile radius area map with NFS as the focal point. The BLEU facility is not shown on this map but is located in between the NFS plant and the Studsvik Processing Facility. Appendix E is the approximate 100-year flood plain supplanted on an NFS and BLEU Complex map. Appendix F provides an aerial view of the BLEU Complex site showing spatial relationships to the NFS and Studsvik Processing Facility sites.

1.1 *Climate*

The climate in the vicinity is characterized by warm, humid summers and relatively mild winters. Cooler, drier weather in the area is usually associated with polar continental air masses, whereas, warmer, wetter weather is generally associated with gulf maritime masses. The average annual temperature in 2000 was 55.1°F. The average daily minimum temperature was 23.8°F in January; and 83.4°F was the average daily maximum temperature in July.

1.2 *Meteorology*

The average annual precipitation in the Erwin area is 41 inches and the average snowfall is 16 inches. Prevailing winds tend to be from the southwest following the orientation of the valley. The 30 year average wind speed is 6.9 mph.

1.3 *Floods*

The Process Hazards Analysis found no credible accident scenario resulting from local area flooding because the storage tanks are bolted in place and the facility is well above the 100-year floodplain Base Flood Elevation. The Town of Erwin participates in the National Flood Insurance Program (NFIP) created by Congress in 1968. Communities that participate in NFIP adopt and enforce floodplain management ordinances that provide flood loss reduction building standards for new and existing development. The lowest floor elevation for buildings that are located in the 100-year floodplain must be at least one (1) foot above the Base Flood Elevation. The UNB is not located in the 100-year floodplain, and the lowest floor elevation is fifteen (15) feet above the Base Flood Elevation, thus a large margin of safety exists.

1.4 *Winds and Storms*

Severe storm conditions are rare in the Erwin region, which is east of the center of tornado activity, south of most blizzard conditions, and too far inland to be affected by hurricane activity. NOAA regional data recorded a maximum sustained wind of 50 mph in 1951, and a peak wind gust of 86 mph in 1995. Wind data from the NFS Site collected over approximately the past three years indicate a maximum sustained wind of 29 mph.

The UNB is designed to withstand design basis winds per the 1999 SBC. See section 3.5 for further discussion.

A risk analysis for the NFS Site indicates a moderate to severe risk of facilities being damaged by lightning. The UNB and BLEU facilities design are reviewed for lightning risk and the appropriate protection is specified. The UNB includes lightning protection per the applicable building codes (specifically NFPA 780). Therefore, lightning strikes would not be a significant concern for the BLEU Complex.

The UNB design and construction is in accordance with the Standard Building Code (1999) with a design wind load of 80 mph. Heavy rain damage to the UNB roof is bounded by snow loading, against which the building is designed per the SBC. Therefore, wind and storms are not of significant concern to UNB operations.

1.5 *Tornadoes*

The only tornado reported in Unicoi County in the last 50 years occurred July 10, 1980. According to NOAA event data, no deaths occurred and only 12 injuries were reported. According to the Johnson City Press, high winds caused damage in the north side of Erwin, and in the Limestone Cove area northwest of Unicoi. These areas are more open than the NFS Site, which is in a fairly narrow valley. The adjacent Tennessee counties of Washington and Carter reported two tornadoes each in the last 50 years, which is also very infrequent.

The annual average number of tornadoes per 10,000 square miles for the State of Tennessee from 1950 – 1995 as reported by NOAA is 2.9. This equates to an average probability of 6.4 E-6 per square mile per year. Since the NFS Controlled Area is 0.047 square miles, the average probability is 3.0 E-7 per year for a direct hit at the NFS Controlled Area. This probability is considered conservative since the NFS Controlled Area (0.047 sq. miles) is not an open area, but bounded by mountain ranges that run in a southwest to northeast direction indicative of the east Tennessee topography. The NOAA statistics bound the entire state of Tennessee, of which a majority of the area is more open topography than east Tennessee. Therefore, the probability of a tornado occurring is even less at the NFS Controlled Area site.

Considering the low probability of a tornado striking the NFS Site, of tornadoes developing in the Unicoi County area, and even lower probability of a tornado developing at the NFS Site, a damaging tornado is not considered a significant concern for site operations. In the event that a tornado did occur on site, protective actions would be implemented in accordance with the NFS Emergency Plan.

1.6 *Seismology*

The NFS site is located within the Southern Appalachian Tectonic Province, which extends from central Virginia to central Alabama and from the western edge of the Piedmont Province to the Cumberland Plateau Province. The Southern Tectonic Province has a moderate level of historical and recent earthquake activity. The NFS Site location is designated as Seismic Zone IIC in the 1999 Standard Building Code (SBC).

A seismic analysis of the NFS Site determined there is no evidence of geologically recent fault displacements on the site that would be associated with capable faults in the surrounding region. For a 1000-year return period, the analysis yielded an effective peak horizontal ground acceleration rate of 0.06 gravity.

The UNB is designed and constructed in accordance with the Standard Building Code (1999). The seismic design specification for all process vessel restraint systems is a value of 0.1 gravity for the effective peak acceleration. Refer to Section 3.5 for further discussion of these features.

1.7 *Population Information*

The NFS facility is located approximately fifty miles north-northeast of Asheville, North Carolina and twenty miles south of Johnson City, Tennessee near the southwest boundary of the Town of Erwin in Unicoi County, Tennessee. According to the 2000 U.S. Census, Erwin has a population of 5,610 and Unicoi County has a population of 17,667. A one mile radius includes portions of residential neighborhoods of Banner Hill, Love Station, and Evergreen. The estimated population density within one mile of the Complex is approximately 2,800 people.

1.8 *Adjacent Facilities*

1.8.1 Studsvik Processing Facility

The Studsvik Processing Facility (SPF), owned by Studsvik, LLC, is a State of Tennessee licensed low level radioactive waste processing facility located greater than 223 feet southwest of the Complex site boundary. The SPF processes low level contaminated ion exchange resins from secondary coolant operations at nuclear power plant facilities. The total average inventory of radioactivity during 2001 was approximately 900 curies, with the following radionuclides providing significant contributions (>1%) to the inventory: Co^{58}, Co^{60}, Mn^{54}, Fe^{55}, Cs^{134}, Cs^{137}, and Ni^{63}.

A failure of engineering controls at Studsvik could potentially lead to a release of radiological materials to the air. However, because of its source term, the facility constitutes a low hazard facility, which State of Tennessee regulations exempt from having an Emergency Plan. In the event that a radiological release should occur, Studsvik would notify BLEU Complex of appropriate protective actions to take. Additional response measures may be taken by NFS, which may include the activation of its Emergency Response Organization. The response would be initiated in accordance with the NFS Emergency Plan.

Scenario 13, Studsvik Bulk Chemical Storage Accident, would most likely be bounded by Scenario 9, NFS Bulk Chemical Storage Accident.

Studsvik uses bulk NaOH inside the process facility building, and liquid nitrogen and liquid oxygen tanks located on the west side of their process building. In addition, a diesel fuel tank is located on the south east side of their process facility. Below are the tank sources, capacities, pressures and locations relative to the Studsvik process facility.

1.8.2 CSX Transportation Railroad Yard

The railroad is approximately 220 feet from the UNB. The rail yard speed limit is 10 mph. All trains stop in the rail yard; there are no tracks that pass straight through. The bounding fire from a radiant heat exposure to the UNB would be an LPG railcar BLEVE. As stated above, a BLEVE creates a large rising fireball of very short duration, which presents a radiant heat and burn injury exposure to people who may be outside and not in fire-rated protective clothing. A BLEVE does not produce remote overpressures and would not present a significant thermal exposure to the UNB from a property damage standpoint.

LPG rail cars have very strict design and operational requirements. In addition to the mechanical standards common to all freight cars, they must also meet the requirements of both DOT 49 CFR Part 179 and the Association of American Railroads (AAR) Specifications for Tank Cars. Builders must seek design approval from the AAR Tank Car Committee before building a tank car. Repairs must be performed only by facilities certified by the AAR. Normally, the maximum LPG rail car inventory is 30,000 gallons (approx. 85% fill density).

Thermal insulation systems are installed to aid LPG tank cars in resisting the effects of fires in derailments. Heat shields are required to minimize damage to the tank car heads. Thermal protection, not to be confused with insulation, is installed on LPG tank cars to protect the tank from flame impingement. It is designed to keep tank metal temperatures below 800°F for 100 minutes (pool fire impingement) and 30 minutes from direct torch fire impingement.

Since the implementation of stricter design standards (required for new cars beginning in 1978 - retrofit of existing cars was completed in 1981), there have been no reports of major BLEVE or vapor explosion incidents involving these cars although a number of minor derailments have occurred.

Based on an LPG tank car being parked in the CSX rail yard, with no loading or unloading operations, and based on the very strict tank car designs with no BLEVEs or vapor cloud explosions occurring over the last 21 years, the likelihood of having an LPG tank car BLEVE or explosion exposing UNB is not considered a significant concern for site operations.

Due to the various types of hazardous materials carried by the railroad, in addition to railroad refueling operations, there is a potential for the Complex to be impacted by fire, explosion or hazardous chemical releases from the railroad yard. The potential fire and explosion scenarios from the railroad are addressed in the BLEU Complex FHA, and would be bounded by the on-site fire and explosion hazards already analyzed. In the event that a fire, explosion, or hazardous chemical release occurred, protective actions (e.g., evacuation or shelter) would be initiated in accordance with the NFS Emergency Plan.

1.8.3 NFS Bulk Chemical Storage

The following table presents the location, contents, and estimated volumes and pressures of the chemicals stored in the NFS Bulk Chemical Storage Area.

Bulk Chemical Storage
(From Table 1-3 of NFS Emergency Plan)

Chemical	Quantity (gallons)	Storage Location	Classification	Pressure	Comments

Chemical	Quantity (gallons)	Storage Location	Classification	Pressure	Comments

Chemical	Quantity (gallons)	Storage Location	Classification	Pressure	Comments

BCSA: Bulk Chemical Storage Area (Section 15.10.5.3 of License SNM-124)

Scenario 9, NFS Bulk Chemical Storage Accident, would most likely be bounded by scenarios involving hydrogen storage vessels. Approximately 400 feet north of the UNB, there is a 1,500-gallon liquid hydrogen tank and a backup bank of six (6) horizontal tanks containing gaseous hydrogen (each tube is approximately 54 cubic feet). In the same area, there is a 1,000-gallon liquefied propane gas (LPG) tank. Also, the delivery truck routes for both hydrogen and propane are approximately 410 feet from the UNB.

The primary exposure from these tanks and delivery trucks is from a BLEVE (boiling liquid expanding vapor explosion). A BLEVE creates a large rising fireball of short duration, which presents a radiant heat and burn injury exposure to people who may be outside and not in fire-rated protective clothing. A BLEVE does not produce remote overpressures and presents an insignificant thermal exposure from a property damage standpoint.

A hydrogen unconfined vapor cloud explosion (UVCE) is not a credible event due to the vapor density and dispersion characteristics of hydrogen. The LPG tank size (1,000 gallons), and location (in the open), make the likelihood of an UVCE highly unlikely. The outside hydrogen and propane tanks present an insignificant exposure to process operations inside the UNB.

1.8.4 Local and Regional Airports

The Tri-Cities Regional Airport is located approximately 40 miles north of the BLEU Complex near the town of Gray, which is centrally located between the three major cities of Kingsport, Bristol, and Johnson City. The airport consists of an 8,000 foot primary east-west runway and a 4,447 foot secondary north-south runway. The flight patterns for airliners arriving and departing from the runways do not cross over the NFS site. Considering the relatively small size of the airport, and significant distance from the site, the air traffic from this airport does not represent a significant concern for the Complex.

Other local airports are operated in Johnson City and Elizabethton, however, these are small operations and at least 25 miles from the Complex. The flight patterns to these airports are not a concern for site or BLEU Complex operations.

1.8.5 Carolina Avenue

Carolina Avenue runs parallel to the east property boundary of the Complex. There is only one access point to the site from Carolina Avenue. The vehicle traffic on Carolina Avenue has not been specifically evaluated, however, the road is approximately 500 feet from the site boundary. Considering this distance, vehicles on Carolina Avenue would not be a significant concern for site operations.

2.0 *Facility Description*

The BLEU Complex is located on approximately five acres of land adjacent to NFS' normal processing area. The property lies approximately 800 to 1000 feet from the southeastern bank of the Nolichucky River, and is bounded by Carolina Avenue to the east, the CSX rail yard to the west, NFS to the north and the Studsvik Processing Area to the south. (See Figure 1).

Figure 1: BLEU Complex Site Plan

The BLEU Complex is fenced and has a 24-hour guard station at the entrance. Site layout concerns that are related to the processing of nuclear materials and worker safety are specifically addressed by the Nuclear Criticality Safety Evaluation and the Radiation Protection Program. On-site traffic patterns do not appreciably increase the accident likelihood for the UNB. Evacuation routes and emergency vehicle access to the site are designed such that egress during an accident does not increase the risk to employee health nor impede site access for emergency personnel.

3.0 Process and Accident Scenario Descriptions

This section describes the UNB processes and the associated high consequence accident scenarios that were identified in the PHA. Table 1 lists these accident scenarios, summarizing the hazards and the controls implemented to meet the performance criteria. Also, Section 3.4 describes non-process related accident scenarios (e.g. fire) that result in intermediate or high consequences if unmitigated.

3.1 *UN Receipt Process Description*

3.1.1 UN Receipt Equipment

3.1.2 UN Receipt Process

Figure 2: UNB Process Flow Diagram

3.1.3 UN Receipt Hazards

Consequence assessments applied to the PHA determined that the only UNB Facility process-related hazards that exceeded the 10 CFR 70.61 performance criteria were nuclear criticality related. Fire, chemical, radiological, industrial, and nuclear safety elements are evaluated for the process and for natural phenomena and external events in the PHA. Non-process related hazards are discussed in section 3.4. Refer to section 4.2 for an overview of the PHA process and section 4.7 for an overview of the consequence analyses.

3.1.4 UN Receipt Accident Scenarios

The ISA identified several accident scenarios that could lead to unacceptable safety consequences for the UNB process systems. These scenarios are listed in Table 1, along with consequence and likelihood ratings and measures (IROFS) taken to reduce the risk to acceptable levels.

The initiating event number in the first column of Table 1 is the same identifier used in the PHA accident scenario tables. The Initiating Event Index in column (2) is taken from Table 3 (Section 4.7.2) below. The preventive and/or mitigative IROFS are listed in columns (3)-(5), along with a failure index from Table 4. The calculated Likelihood Index T is shown in column (6). The uncontrolled value of T is just the initiating event frequency index. The controlled T is the sum of columns (2) through (5). From T, a Likelihood Category is derived per Table 6 for both uncontrolled and controlled cases. The Consequence Category is selected based on the severity of the consequence per Table 2. The Risk Indices are calculated by multiplying the values in column (7) by column (8). The result is compared to the Risk Matrix in Table 7 to determine if sufficient protection has been provided. All of the scenarios have a Consequence Category of 3, and so must be controlled to "Highly Unlikely", so the Risk Index must be equal to 3 for each scenario.

Scenarios 1.5.1 through 1.62.1 relate to the UN Receipt processes described above. All of the scenarios are criticality safety issues, specifically related to loss of concentration control leading to a potential criticality. The initiating events and IROFS for the scenarios listed in Table 1 are explained in more detail below.

Scenario 1.5.1:

This scenario results in a transfer to the UNB equipment of UN either exceeding 5 wt.% ^{235}U or exceeding 210 g U/l caused by supplier error.

Scenarios 1.5.2, 1.7.1, and 1.18.1:

These scenarios result in an increase in Uranium concentration via crystallization caused by low temperature of the UN being transferred to the receipt tank (TK-10) from the LR-230 shipping containers.

Scenarios 1.25.1, 1.38.1, 1.54.1, 1.55.1, 1.59.1, 1.61.1, and 1.62.1:

These scenarios result in U carryover to the ductwork via TK-10 caused by either overflow from TK-10 or failure of the TK-10 off-gas de-mister pad to de-entrain UN from the off-gas. Overflow to the ductwork is not an immediate concern. It becomes a concern if it is not identified and appropriate corrective action is not performed to remove the liquid and prevent concentration.

Scenario 1.26.1:

This scenario results in UN with increased U concentration pumped to TK-10 via the off-spec material feed line (from the UNB spill basin sump) following a spill inside the facility and concentration of the solution via evaporation

Scenario 1.12.1:

This scenario results in a transfer of a precipitating agent to the UNB equipment from a LR-230 container. A *shipper error causes filling of one or more* LR-230 with a *precipitating agent* and subsequent transfer of this solution to TK-10.

Scenario 1.12.2:

This scenario results in an increase in U concentration via precipitation caused by introduction of a precipitating agent into TK-10 from the UN download area. An operator hooking up an incorrect tank (non LR-230) that contains a precipitating agent to TK-10 feed line causes this event.

Scenarios 1.26.2 and 1.76.1

These scenarios result in an increase in U solution concentration in the off-spec UN tank (TK-10U) via evaporation resulting from high ambient temperature and/or high flow through the ventilation system.

Scenario 1.26.3

This scenario results in an increase in U concentration via precipitation caused by introduction of a precipitating agent to TK-10 from the spill basin sump or sink. An operator adding a solution containing a precipitant to the spill basin sump or sink causes this event.

Scenario 1.32.1

This scenario results in reverse flow of UN from TK-10 to either TK-10U or the spill basin. Since this same material would have already been in either TK-10U or the spill basin, this scenario has no significant consequence. If the material didn't achieve criticality in TK-10U or in the spill basin, it will not achieve criticality if it gets back to this equipment.

Table 1: Accident Sequence Summaries Which Require IROFS and Resultant Risk Assignments

(1) Accident Sequence	(2) Initiating Event / Freq Index	(3) Preventive IROFS 1 / Freq Index	(4) Preventive IROFS 2 / Freq Index	(5) Mitigation / Freq Index	(6) Likelihood Index T Uncontrolled / Controlled	(7) Likelihood Category Uncontrolled / Controlled	(8) Consequence / Category	(9) Risk Indices Uncontrolled / Controlled	(10) Comments and Recommendations
1.5.1 High U conc. or %235	Shipper error, unsafe UN received into TK-10 / -3	-1	-2	None	U = -3 / C = -6	U =2 / C = 1	Possible Criticality Accident / 3	U = 6 / C = 3	*High quality vendor process and safety controls make initiating event unlikely.*
1.5.2 UN Receipt High U in TK-10	UN Freezing in Shipping Container / 0	-2	-2	None	U = 0 / C = -4	U = 3 / C = 1	Possible Criticality Accident / 3	U = 9 / C = 3	*This scenario can only occur during transfers (one per week) that take place in extremely cold weather.*
1.7.1 UN Receipt High U in TK-10	UN Freezing in Shipping Container / 0	-2	-2	None	U = 0 / C = -4	U = 3 / C = 1	Possible Criticality Accident / 3	U = 9 / C = 3	*Essentially the same as 1.5.2*

(1) Accident Sequence	(2) Initiating Event Freq Index	(3) Preventive IROFS 1 Freq Index	(4) Preventive IROFS 2 Freq Index	(5) Mitigation Freq Index	(6) Likelihood Index T Uncontrolled Controlled	(7) Likelihood Category Uncontrolled Controlled	(8) Consequence Category	(9) Risk Indices Uncontrolled Controlled	(10) Comments and Recommendations
1.12.1 UN Receipt: High U in TK-10	Precipitant transferred to TK-10 from a LR-130 -3	-1	-2	None	U = -1 C = -6	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*LR-230 are unique to this service, No precipitating agents are allowed in suppliers downloading areas or upstream equipment..*
1.12.2 UN Receipt: High U in TK-10	Operator Transfers Precipitant via Feed Line -1	-3	-1	None	U = -1 C = -5	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*No precipitants (or other chemicals other than UN) are used in the UNB download area.*
1.18.1 UN Receipt High U in TK-10 (Feed Line)	UN Freezing in Shipping Container 0	-2	-2	None	U = 0 C = -4	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*Essentially the same as 1.5.2*
1.25.1 U in Ductwork from TK-10	High Flow in Off-Spec Material Feed Line causes U carryover, w/ subsequent evaporation -1	-3	-3	None	U = -1 C = -7	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*Level controls/interlocks and CCS control of transfers to TK-10 provide added protection against any overfill scenario.*

(1) Accident Sequence	(2) Initiating Event / Freq Index	(3) Preventive IROFS 1 / Freq Index	(4) Preventive IROFS 2 / Freq Index	(5) Mitigation / Freq Index	(6) Likelihood Index T Uncontrolled / Controlled	(7) Likelihood Category Uncontrolled / Controlled	(8) Consequence / Category	(9) Risk Indices Uncontrolled / Controlled	(10) Comments and Recommendations
1.26.1 TK-10 High U Conc.	UN Spill evaporates, high conc. U transferred via pump P-10S -2	-1	-2	None	U = -2 C = -5	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*High integrity primary containment reduces risk of spills. Those spills large enough to cause safety problems are easily detected and cleaned up.*
1.26.2 TK-10 High U Conc from TK-10U	UN in TK-10U evaporates, high conc U transferred to TK-10 -2	-3	-1	None	U = -2 C = -6	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*TK-10U contains UN very infrequently. Tank seal is verified by air flowmeter in common vessel vent line.*
1.26.3 TK-10 High U due to Precip	Operator transfers Precipitating Agent from sink during remediation -1	-2	-1	None	U = -1 C = -4	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*No precipitants are allowed in UNB; only other chemical used in quantity are DIW and possibly dilute HNO_3. This system is infrequently used..*

(1) Accident Sequence	(2) Initiating Event / Freq Index	(3) Preventive IROFS 1 / Freq Index	(4) Preventive IROFS 2 / Freq Index	(5) Mitigation / Freq Index	(6) Likelihood Index T Uncontrolled / Controlled	(7) Likelihood Category Uncontrolled / Controlled	(8) Consequence / Category	(9) Risk Indices Uncontrolled / Controlled	(10) Comments and Recommendations
1.38.1 U in Ductwork from TK-10	TK-10 High level causes overflow to HVAC duct, w/ subseq. Evaporation / -1	-3	-3	None	U = -1 / C = -7	U = 3 / C = 1	Possible Criticality Accident / 3	U = 9 / C = 3	*Essentially the same as 1.25.1.*
1.54.1 U in Ductwork from TK-10	Loss of TK-10 demister, UN carryover and subseq. Evaporation / -1	-3	-3	None	U = -1 / C = -7	U = 3 / C = 1	Possible Criticality Accident / 3	U = 9 / C = 3	*De-entrainment system of TK-10 includes passive-engineered separation design upstream of demister.*
1.55.1 U in Ductwork from TK-10	Compressed air left on, carryover of UN, w/ subseq evaporation / 0	-3	-3	None	U = 0 / C = -6	U = 3 / C = 1	Possible Criticality Accident / 3	U = 9 / C = 3	*Essentially the same as 1.54.1.*

(1) Accident Sequence	(2) Initiating Event Freq Index	(3) Preventive IROFS 1 Freq Index	(4) Preventive IROFS 2 Freq Index	(5) Mitigation Freq Index	(6) Likelihood Index T Uncontrolled Controlled	(7) Likelihood Category Uncontrolled Controlled	(8) Consequence Category	(9) Risk Indices Uncontrolled Controlled	(10) Comments and Recommendations
1.59.1 U in Ductwork from TK-10	Loss of TK-10 demister, UN carryover and subseq. Evaporation -1	-3	-3	None	U = -1 C = -7	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*Essentially the same as 1.54.1.*
1.61.1 U in Ductwork from TK-10	Partial filtration; Loss of TK-10 demister, UN carryover and subseq. Evaporation -1	-3	-3	None	U = -1 C = -7	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*Essentially the same as 1.54.1.*
1.62.1 U in Ductwork from TK-10	Entrainment; Loss of TK-10 demister, UN carryover and subseq. Evaporation -1	-3	-3	None	U = -1 C = -7	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*Essentially the same as 1.54.1.*

(1) Accident Sequence	(2) Initiating Event Freq Index	(3) Preventive IROFS 1 Freq Index	(4) Preventive IROFS 2 Freq Index	(5) Mitigation Freq Index	(6) Likelihood Index T Uncontrolled Controlled	(7) Likelihood Category Uncontrolled Controlled	(8) Consequence Category	(9) Risk Indices Uncontrolled Controlled	(10) Comments and Recommendations
1.76.1 TK-10U High U Conc	UN in TK-10U evaporates over long period of time -2	-3	-1	None	U = -2 C = -6	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*TK-10U is only rarely used and it is unlikely that UN would be left unprocessed in the tank for a long enough time to concentrate to unsafe levels.*
1.106.1 & 1.115.1 Storage Tank High U Conc	UN in any storage tank evaporates due to hi outside temp -3	-2	-1	None	U = -3 C = -6	U = 2 C = 1	Possible Criticality Accident 3	U = 6 C = 3	*It would take over two years for UN to concentrate to unsafe levels under worst case conditions.*
1.109.1 Storage Tank High U Conc by freezing	See Comment →								Scenario bounded by 1.106.1, 106.2, 1.111.1, 1.121.1 and 1.121.2

(1) Accident Sequence	(2) Initiating Event Freq Index	(3) Preventive IROFS 1 Freq Index	(4) Preventive IROFS 2 Freq Index	(5) Mitigation Freq Index	(6) Likelihood Index T Uncontrolled Controlled	(7) Likelihood Category Uncontrolled Controlled	(8) Consequence Category	(9) Risk Indices Uncontrolled Controlled	(10) Comments and Recommendations
1.111.1 & 1.120.1 Storage Tank High U Conc.	UN in storage tank partially freezes due to low outside temp -2	-2	-2	None	U = -3 C = -6	U = 2 C = 1	Possible Criticality Accident 3	U = 6 C = 3	*It takes more than 1 month at temperature of 24 degrees with no heaters in the UNB for UN in worst case scenario to begin to crystallize and cause unsafe conditions.*
1.121.1 High U Conc in HVAC duct	UN overflows from storage tank, subseq. evaporation 0	-3	-3	None	U = 0 C = -6	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*Each tank has dual level alarms and feed is interlocked upon high level, reducing risk of overflow (these controls are not credited in likelihood).*
1.121.2 High U Conc in HVAC duct	UN overflows from storage tank due to mech failure, subseq. evaporation 0	-3	-3	None	U = -1 C = -6	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*Same as above. Also, the UN would have to collect and evaporate in the HVAC duct for a long enough time to exceed safe slab depth.*

(1) Accident Sequence	(2) Initiating Event Freq Index	(3) Preventive IROFS 1 Freq Index	(4) Preventive IROFS 2 Freq Index	(5) Mitigation Freq Index	(6) Likelihood Index T Uncontrolled Controlled	(7) Likelihood Category Uncontrolled Controlled	(8) Consequence Category	(9) Risk Indices Uncontrolled Controlled	(10) Comments and Recommendations
1.132.1 & 1.132.2 High U Conc storage tank	During UN transfer to OCB, backflow of precipitating agent occurs due to overflow -1	-3	-3	None	U = -1 C = -7	U = 3 C = 1	Possible Criticality Accident 3	U = 9 C = 3	*TK-20 and TK-21 have level alarms and interlocks as well. Backflow could only occur during transfer, so would also have to overcome pressure gradients.*
Fire Scenario 29: Natural gas explosion	Explosion causes damage to storage tanks, releasing UN to environment 0	-2	-2	None	U = 0 C = -4	U = 3 C = 1	Environmental Damage 3	U = 9 C = 3	Not a process hazard – see Appendix B, scenario 29
Fire Scenario A: FRP Tank Fire	Fire causes damage to FRP tanks, releasing UN to the UNB sump and outside environment -1	-2	-1	None	U = -1 C = -4	U = 3 C = 1	Environmental Damage 3	U = 9 C = 3	Not a process hazard

Note: IROFS UNB-C, UNB-J, UNB-K, and UNB-R are assigned conservative IROFS Failure Indices. The 8 accident sequences affected are 1.5.1, 1.12.1, 1.12.2, 1.26.2, 1.26.3, 1.76.1, 1.106.1, and 1.115.1. In each of the 8 cases, the accident sequences meet the 10 CFR 70 Subpart H performance requirements. Assignment of the less conservative indices as provided in Table 4 will also result in the sequences meeting the performance requirements. Most of the accident sequences meet the performance criteria based on a large index margin provided for by the assigned initiating event index and/or an additional IROFS engineering control preventing or mitigating the accident sequence.

3.2 *UN Storage Process Description*

3.2.1 UN Storage Equipment

3.2.2 UN Storage Process

There are five basic operations performed with these tanks and associated equipment: filling from TK-10; storage; recirculation; transfer between storage tanks; and transfer to the OCB.

As previously discussed, an additional tank (TK-10U, utility) is available in the area for off-spec material or spill clean-up. Any transfers to TK-10U first undergo parameter monitoring in TK-10 and can then be monitored independently in TK-10U (in-tank density and level, plus the recirculating density).

3.2.3 UN Storage Process Hazards

The PHA and ISA determined that the only UNB Facility process-related hazards that exceeded the 10 CFR 70.61 performance criteria were nuclear criticality related. Fire, chemical, radiological, industrial, and nuclear safety elements are evaluated for the process and for natural phenomena and external events in the PHA

3.2.4 UN Storage Accident Scenarios

Accident scenarios 1.106.1 through 1.132.1 in Table 1 relate to the UN Storage systems. The initiating events and IROFS for the scenarios listed in Table 1 are explained in more detail below:

Scenarios 1.106.1, and 1.115.1

These scenarios result in an increase in U solution concentration in the UN storage tanks (TK-11A through 14F) via evaporation resulting from high ambient temperature and/or high airflow through the ventilation system.

Scenario 1.109.1

This scenario results in a localized increase in Uranium concentration in the UN storage tanks (TK-11A through 14F) via precipitation or crystallization. The initiating events for this scenario are the same as those for scenarios 1.12.2, 1.26.2, 1.106.1, 1.111.1, 1.132.1, and 1.132.2. Therefore, this scenario is bounded by scenarios 1.12.2, 1.26.2, 1.106.1, 1.111.1, 1.132.1, and 1.132.2.

Scenarios 1.111.1 and 1.120.1

These scenarios result in an increase in U concentration in one or more of the UN storage tanks (TK-11A through 14F) via crystallization resulting from low ambient temperature.

Scenarios 1.121.1 and 1.121.2

This scenario results in U carryover to the ductwork from the UN storage tanks. As discussed above for TK-10 (scenario 1.25.1, etc.), carryover of UN to the ductwork is not an immediate concern. It becomes a concern if it is not identified and appropriate corrective action is not performed to remove the liquid and prevent concentration. An overflow condition is readily detected by the CCS, which monitors the level of solution in the UN storage tanks. An overflow condition is detected by the CCS, which monitors the level of solution in the UN storage tanks. Only a complete failure of the CCS, along with failure of all fail-safe modes, and complete inattention by the operating staff could cause an overflow to go undetected.

Scenarios 1.132.1 and 1.132.2

This case results in U precipitation in the UN storage tanks after backflow from the OCB precipitation tank TK-21. UN from the UNB is transferred to UN Feed Tanks in the OCB. This UN is then transferred to the precipitation tank TK-21. Only a complete failure of the CCS, along with failure of all fail-safe modes, and complete inattention by the operating staff could cause an overflow to go undetected. Note that these scenarios will be re-evaluated and updated before startup of the OCB operations.

3.3 *Natural Uranyl Nitrate (NUN) Storage Process Description*

Natural UO_3 will be dissolved in the OCB and the resulting uranyl nitrate collected in a storage tank located in the UNB, from where it will be downloaded into tanker trucks. The storage tank TK-18 and download station were installed during UNB construction but the equipment will not be placed in service until mid-2004. Installation of the equipment was evaluated in the UNB PHA, and an evaluation of the operation of this system has been performed with the OCB safety evaluations. The system will remain isolated until NUN operations commence in mid-2004.

3.4 *Non-Process Hazards Description*

External events and fire hazards were analyzed in the PHA and FHA and the following two intermediate or high consequence scenarios were identified (Scenarios 29 and A). See Section 4.2 for an overview of the PHA and Appendix B for a summary table of the external events that were analyzed.

An evaluation of natural phenomena hazards revealed three scenarios that could lead to consequences exceeding the Performance Criteria if unmitigated. Structural features were incorporated into the facility and equipment per standard building codes to meet the Part 70 requirements for these accident scenarios (see Non-Process Hazard Scenarios S1, S2, and W1 below).

PHA Non-Process Hazards Scenario 29

This scenario consists of loss of U containment due to a natural gas explosion in the mechanical room that causes potentially high level consequences due to environmental and health physics effects resulting from the failure of more than one of the storage tanks in the UNB. Refer to Scenario 29 in Appendix B for more detail on this scenario.

Contingency #1: A combustible gas monitor is provided in the mechanical room that will trigger a block and bleed on the natural gas supply line if natural gas is detected in the room. A low pressure switch on the gas line activates the block and bleed as well. This control fails safe on loss of power (shutoff valves fail closed, vent valve fails open, low pressure switch fails open, alarm contacts on combustible gas monitors fail open).

Contingency #2: An independent combustible gas monitor is provided in the mechanical room that will close an independent block valve on the natural gas supply line if natural gas is detected in the room. This control fails safe (the valve closes) on loss of power.

Defense in depth: The natural gas burner system has internal controls to prevent leakage (flame detector, etc.) and potential natural gas fires. The automatic fire suppression system will stop any fire before significant damage could occur. The main process area ventilation system uses a natural gas burner heating system. The natural gas supply and burner system is designed, installed, and maintained per the applicable portions of NFPA 54. The 375,000 BTU/hr rated burner, burner controls, and heat exchanger are located in the mechanical room as part of the air handling unit. The underground natural gas supply line comes through double-block-and-bleed isolation valves and an independent isolation valve in the feed line outside of the building. Two independent combustible gas detectors inside the mechanical room interlock these valves. These interlocks fail safe – on loss of power, the valves close. A 12" CMU block wall separates the mechanical room from the main process area. The nearest storage tank is approximately 15 feet from the burner.

PHA Non-Process Hazards Scenario A

Any fire scenario severe enough to make even one FRP tank catch fire is unlikely due to the lack of combustible materials in and around the facility, the material properties of the FRP tanks as specified in Reference 9, and the presence of operating and security personnel in the UNB. However, it is assumed that if a fire was initiated, the ensuing environmental and health physics consequences would be High. Therefore, the Active Engineering Control (AEC), UNB automatic sprinkler system, and the Administrative Control, a trained operator performing a routine task with an approved procedure, are designated as IROFS to prevent and mitigate any fire accident sequence that ignites and causes the FRP tanks to fail (excluding Scenario 29). In addition, designating these as IROFS and applying the management measures specified in Section 4.8 of this Summary to ensure they are available and reliable when called upon to function satisfies the performance criteria set forth in 10 CFR 70.61.

Contingency #1: The automatic sprinkler system will stop any fire before significant damage could occur to more than one tank. The UNB sump is designed to contain the contents of one tank plus the sprinkler system discharge for 30 minutes.

Contingency #2: A trained operator performing a routine task with an approved procedure will sufficiently prevent the accident sequence initiation. However, should the initiating event occur the operator will perform the required operations as trained to prevent and mitigate the accident sequence.

Operators working in the UNB facility will receive training regarding recognition of potential fire hazards along with response/notification actions to be taken in the event a fire occurs. Procedures governing fire safety will be provided to address control of combustibles, emergency response, fire protection equipment maintenance and inspection, and actions to be taken with regard to fire system impairments.

Work involving welding, cutting, and other flame/spark producing activities will also be addressed by procedure. This procedure will include protection of adjacent combustible materials, pre-job notification of appropriate safety and operations personnel, and requirements for fire watch personnel. These issues will be addressed through a "hot-work" permit process. Persons acting in a firewatch capacity will be provided "hands-on" training on fire extinguisher use.

Defense in depth: The building is constructed of non-flammable materials, no significant amounts of combustible materials are stored in or around the building, the site is kept free of brush, etc. Further, an intumescent coating was applied to each of the FRP tanks in the UNB as good engineering practice that will reduce the likelihood of flame spread and smoke generation if one of the tanks were to catch fire. Finally, a fire alarm system is provided throughout the facility per NFPA requirements that will provide early alert to a fire.

3.5 Natural Phenomena Hazards Description

An evaluation of natural phenomena hazards revealed three scenarios that could lead to consequences exceeding the Performance Criteria if unmitigated. Structural features were incorporated into the facility and equipment per standard building codes to meet the Part 70 requirements for these accident scenarios (see Non-Process Hazard Scenarios S1, S2, and W1 below).

Natural Phenomenon Hazards Scenario S1
In a design basis earthquake, an inadequately designed building could collapse, leading to release of uranyl nitrate to the environment that could exceed the baseline design threshold as defined in Appendix A (a)(2). The structural features of the UNB design that are required to meet the SBC 1999 code requirements for seismic acceleration factors are designated IROFS UNB-X. Appropriate management measures as listed in Appendix A (a)(2) are applied to assure that the UNB was designed, built, and is maintained to building code requirements.

Natural Phenomenon Hazards Scenario S2
In a design basis earthquake, the fiberglass storage tanks could move to the extent that connecting piping or nozzles might fail, leading to release of uranyl nitrate to the environment that could exceed the baseline design threshold as defined in Appendix A (a)(2). Each fiberglass storage tank in the UNB is equipped with a seismic restraint system designed to keep the tanks stationary during up to a SBC 1999 design basis earthquake. These restraint systems (which are all identical) are designated IROFS UNB-Y. Appropriate management measures are applied to assure that the tank restraint system was designed, built, and is maintained to building code requirements.

Natural Phenomenon Hazards Scenario W1
Design basis high winds could cause an inadequately designed building to collapse, leading to release of uranyl nitrate to the environment that could exceed the baseline design threshold as defined in Appendix A (a)(2). The structural features of the UNB design that are required to meet the SBC 1999 code requirements for wind load factors are designated IROFS UNB-Z. Appropriate management measures as listed in Appendix A are applied to assure that the UNB was designed, built, and is maintained to building code requirements.

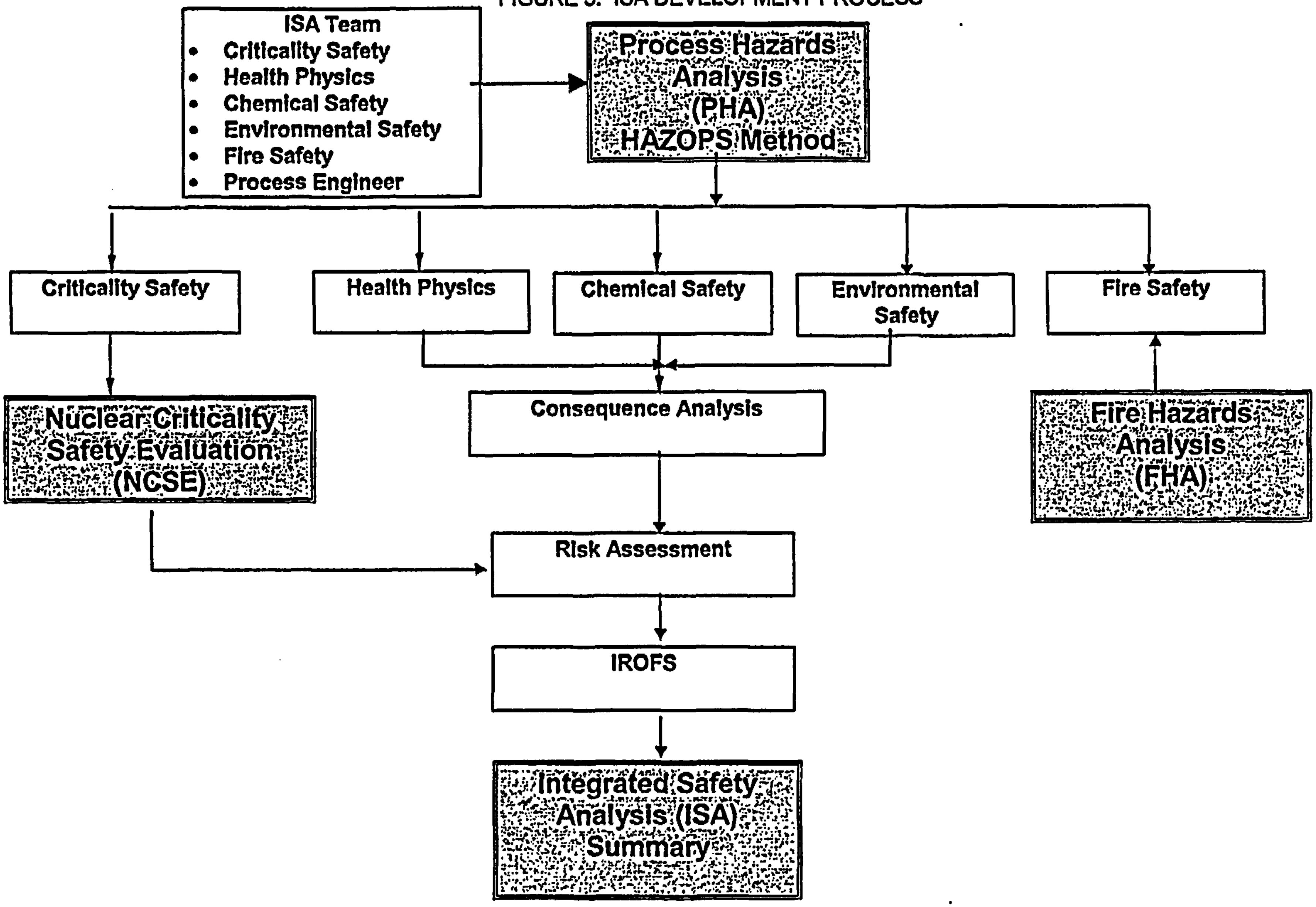
4.0 Compliance with 10 CFR 70.61

This section demonstrates how the ISA procedure complies with the requirements of 10 CFR 70.61.

4.1 *ISA Procedure*

The UNB ISA is conducted in stages as depicted in Figure 3. First, individual and specific hazards analyses are performed to identify hazards and accident sequences. The next step in the process is the consequence assessment and risk categorization of all accident sequences identified. Finally, Items Relied on for Safety (IROFS) are identified which control all accidents resulting in consequences of concern to an acceptable risk. The shaded blocks in the Figure represent separate documents.

FIGURE 3: ISA DEVELOPMENT PROCESS



Individual and specific hazards analyses are conducted by industry approved methods to identify specific hazards, process upsets, accident conditions, causes for the accident condition, and potential consequences. After the accident sequences have been identified, a consequence analysis is performed to identify 'Intermediate' and 'High' consequence events. Integration accomplishes the final two steps of the ISA procedure. Accident sequences resulting in consequences of concern are further defined and potential consequences are compared to the performance criteria listed in 10 CFR 70.61. The charter of the ISA is to review the accident sequences for risk, and identify appropriate controls and/or mitigation to control the risk to an acceptable level.

4.2 *Process Hazards Analysis*

A Process Hazards Analysis (PHA) is a systematic approach for identifying hazards and accident conditions that could result in undesirable consequences for a process or activity. A PHA is conducted on each process system with joint consideration of radiological, criticality, fire, and chemical hazards using appropriate methodologies as described in *Guidelines for Hazard Evaluation Procedures, Second Edition*, (Reference 1). A qualified team is utilized in the conduct of the PHA. Specifically included in the PHA team meetings are; 1) a team leader trained in the methodology(ies) being used, 2) a person familiar with the design, and operation of the process, 3) one or more persons familiar with radiological, chemical, fire, and criticality safety. The complete analysis comprises two segments.

The first segment of the analysis focuses on the process design, equipment, and operations using the Hazard and Operability Analysis (HAZOP) method described in Section 4.2.1. This segment encompasses all of the unit operations housed in the UNB as well as UN solution downloading from transport containers, natural UN solution (NUN) transfers from the OCB, and NUN loadout to tanker trucks.

The second segment of the analysis focuses on natural phenomena and external events that could potentially effect plant equipment and operations or be hazardous to on-site personnel. This segment of the analysis is described in Section 4.2.2.

In general, the PHA is very thorough due to the use of an appropriate methodology, but identified accident scenarios are somewhat broadly defined. Better definition, risk categorization and identification of control is accomplished during integration of the analyses. Because the PHA is so thorough and has representation from all disciplines, it is considered the foundation for subsequent ISA steps. Reference 10 is the PHA for the UNB.

4.2.1 <u>HAZOP Analysis</u>

During the conduct of the PHA, process safety information is collected then reviewed for completeness. The team leader then selects the methodology to be used for identifying accident sequences. Selecting the most appropriate methodology is important for efficient and effective execution of the hazards analysis. Reference 1 contains a listing and discussion of the various methodologies. Directions for selecting the most appropriate methodology and a decision tree to aid in the selection process are provided.

The "HAZOP" methodology was selected for this segment of the analysis which focuses on the process design, equipment, and operations. The principal justification for this choice is the fact that these systems are primarily chemical and/or process in nature. Using the decision tree,

Figure 5.3 in Reference 1, confirms that the HAZOP methodology is preferred in this analysis for the following reasons:

1. This is a new Hazard Evaluation study.
2. The desired outcome is a list of specific accident situations and safety improvements.
3. Detailed quantitative results are not necessary.
4. Process is not operating.
5. Detailed design information is available.
6. Single and multiple failure events.
7. Perceived High risk.
8. Not a mechanical or electrical system.
9. Not a simple or small system.

Following the branches of the decision tree shows that the HAZOP methodology is appropriate for both single AND multiple failure events for this system.

The reader is referred to Reference 1 for detailed descriptions of the methodologies and appropriate applications.

The basic premise of the HAZOP technique is to divide the process system into small pieces called 'study nodes'. The study nodes for the UNB processes were defined by team members based on process knowledge and are listed in the Node Table. Figure 4 shows the UNB process flow diagram with study nodes identified as encircled numbers that correspond to the numbers in the first column of the Node Table. The last column of the table gives a description of the intended design function and operational parameters for each node. The function and/or parameters are used with a series of "Guide Words" that are applied to each node to identify potential deviations from the plant's intended operation. An example of this methodology follows the table and flow diagram below.

Node Table: Study Nodes for UNB Hazards Analysis

Node	Name	[illegible] Design Intent

Figure 4: UNB Nodes for HAZOP Study

At each study node, the following guide words are applied to the function and/or process parameters to identify potential deviations.

Guide Word	Meaning
No	Negation of the Design Intent
Less	Quantitative Decrease
More	Quantitative Increase
Part Of	Quantitative Decrease
As Well As	Quantitative Increase
Reverse	Logical Opposite of the Design Intent
Other Than	Complete Substitution

4.2.2 Natural Phenomena, External Events, and Site Layout Analysis

This segment of the analysis focuses on natural phenomena, external events, and general site layout factors that could potentially effect process equipment, operability, or be hazardous for on-site personnel. Considerations include:

Natural Phenomena (including earthquake, flooding, windstorm, lightning, tornado, hurricane)

External hazards (including accidents at nearby facilities, aircraft or traffic accident, natural or man-made off-site fire)

Site evacuation

On-site accidents (including fire scenarios for standby generator, propane tank, tow vehicle in unload area, UN storage tank, HVAC natural gas heater, electrical room, mechanical room, office area, lightning strike)

Location of on-site populations relative to the facility

Location of critical systems

Potential for interaction with adjacent systems

On-site traffic patterns (pedestrian and motor vehicle)

Evacuation routes, emergency exits, safe gathering places

Access for fire fighting and other emergency services

Refer to Appendix B for a complete listing of the external event scenarios considered and the results of the analyses (extracted from the PHA, Reference 10).

4.3 *Nuclear Criticality Safety Evaluation(s)*

Nuclear Criticality Safety Evaluations (NCSEs) are specialized studies that assure the risk of having a criticality accident is 'Highly Unlikely' and that the double contingency principle is satisfied. NCSEs are required for all nuclear facilities and the contained fissile material units and/or arrays. These evaluations provide the technical bases for limits and controls to assure criticality safety. Highly skilled and extensively trained personnel in the area of criticality safety perform NCSEs. In addition, a multi-disciplined team reviews all accident sequences, barriers, and bounding assumptions used in the evaluations. Reference 11 is the NCSE for the UNB.

4.4 *Fire Hazards Analysis*

Fire Hazards Analyses (FHA) are conducted for processing buildings which are located within the BLEU Complex site boundary. The charter of the FHA is to evaluate the facility design with respect to fire safety codes, and to ensure that the facility is built such that there is acceptable risk for postulated fire accident scenarios. The FHA is generally conducted by an outside consultant that specializes in fire safety. Reference 9 is the FHA for the UNB.

4.5 *ISA Team*

An ISA Team shall consist of 5-8 members (the team may include more members if necessary). The minimum team shall meet the requirements of 10 CFR 70.62. Refer to section 5.0 for a listing of the personnel that made up the evaluation team for this ISA.

The team is required to have at least one member knowledgeable in each of the following areas for the subject system: 1) criticality safety, 2) radiological safety, 3) fire safety, 4) chemical process safety, 5) process/equipment engineering, and 6) process operation. A single member may be knowledgeable in more than one area and therefore may be relied upon to provide analysis expertise in more than one area. The Team will consult with additional safety, operations, engineering and maintenance personnel on an as-needed basis.

The ISA Team Leader is expected to be cognizant of the requirements for Integrated Safety Analyses as prescribed in 10 CFR Part 70 as well as the applicable NRC guidance in NUREG-1520 Chapter 3, Integrated Safety Analysis (ISA). Guidance is also provided in NUREG-1513, and the AIChE publication, "Guidelines for Hazard Evaluation Procedures."

4.6 *Integration*

To meet NRC requirements the ISA will, strictly speaking, be concerned only with high or intermediate consequences and the IROFS necessarily applied to them. The ISA is intended to give assurance that the potential failures, hazards, accident sequences, scenarios, and IROFS have been investigated together so as to adequately consider common mode and common cause situations, impacts of IROFS that may be simultaneously beneficial and harmful with respect to different hazards, and interactions that may not have been considered in previously completed analyses.

Some items that warrant special consideration during the integration process are:

- External events. This is due to the broad effects they will usually have on the entire plant site, and because they may not have been fully considered in the individual analyses, which were directed principally toward internal events.
- Common mode failures and common cause situations.
- Closely allied to common cause situations are utility system losses, e.g., loss of electrical power or city water, which can have simultaneous effects on multiple systems.
- Divergent Impacts of IROFS. Assurance must be provided that the negative impacts of an IROFS, if any, do not outweigh its positive impacts; i.e., to ensure that the application of an IROFS for one situation does not degrade a different risk situation. The standard example is use of water in a fire situation, which can add moderation with respect to criticality control.
- Other safety and mitigating factors that do not achieve the status of IROFS that could impact system performance.
- Identification of scenarios, events, or event sequences with multiple impacts, i.e. impacts on chemical safety, fire safety, criticality safety, and/or radiation safety e.g., a flood might cause both loss of containment and moderation impacts.
- Potential interactions between processes, systems, areas, and buildings; any interdependence of systems, or potential transfer of energy or materials.
- Major hazards or events, which tend to be common cause situations leading to interactions between processes, systems, buildings, etc.

In this ISA, the Fire Hazards Analysis and Criticality Safety Analyses were reviewed and it was deemed that the accidents in each were either evaluated from the PHA, or bounded by scenarios that were evaluated from the PHA.

4.7 *Risk Categorization*

The Integrated Safety Analysis (ISA) is required to be conducted by the licensee to determine whether the performance requirements listed in 10 CFR 70.61 are met. This requires the identification of all credible High and/or Intermediate consequence accident sequences and an evaluation with respect to the performance requirements. That is, all credible High consequence accident sequences and all credible Intermediate consequence accident sequences shall be shown to be Highly Unlikely and Unlikely respectively, upon application of Items Relied on for

Safety (IROFS). Risk Assessment, as described below, presents a consequence-likelihood risk assessment method by which this evaluation is performed.

4.7.1 Consequence Category

For each credible accident sequence identified, a Consequence Category is assigned. The Consequence Category is assigned based on hazards analysis(es) results, past experience, industry standards, engineering judgment, analytical data, and/or any other applicable information. In addition, the potential consequences are compared against bounding accident sequences. The Consequence Categories are defined in Table 2 as follows:

Table 2: Consequence Severity Categories Based on 10 CFR 70.61

	Workers	Offsite Public	Environment
Consequence Category 3: High	TEDE ≥ 100 rem ≥ ERPG3	TEDE ≥ 25 rem 30 mg soluble Uranium Intake ≥ ERPG2	
Consequence Category 2: Intermediate	25 rem ≤ TEDE < 100 rem ≥ ERPG2 But <, ERPG3	5 rem ≤ TEDE < 25 rem ≥, ERPG1 But < ERPG2	Radioactive Release averaged over a 24 Hour Period of > 5000 x Table 2 Appendix B 10 CFR 20
Consequence Category 1: Low	Accidents of lesser radiological and chemical exposures to workers than those above in this column	Accidents of lesser radiological and chemical exposures to workers than those above in this column	Radioactive releases producing effects less than those specified above in this column.

Note: AEGL, PEL, TEL, or IDLH values are used as justified when ERPG values do not exist.

Consequence Categories for all credible High or Intermediate consequence accident scenarios are assigned and documented in Table 1, Column 8.

4.7.2 Initiating Event Frequency

For each credible accident sequence, the initiating event leading to the accident is identified. If a single initiating event cannot be identified, the conditions that must be met to create the accident are analyzed.

An Initiating Event Frequency Index is assigned to each credible accident scenario based on past experience, engineering judgment, analytical data, industry acceptable values, and/or any other applicable information. Initiating Event Frequency is defined as the probability of occurrence of the initiating event or initiating set of conditions. The index assignments are defined in Table 3.

Table 3: Initiating Event Frequency

Frequency Index	Failure Frequency	Description	Comments
-5	1 Failure/100,000 years	Not credible	If initiating event, no IROFS needed
-4	1 Failure/10,000 years	Physically possible, but not expected to occur.	
-3	1 Failure/1,000 years	Not expected to occur during plant lifetime.	
-2	1 Failure/100 years (Loss of cooling (redundant cooling water pumps)) (Loss of Power (redundant power supplies))	Not expected, but might occur during plant lifetime.	
-1	1 Failure/10 years	Expected to occur during plant lifetime.	
0	1 Failure/year (Loss of cooling) (Loss of Power)	Expected to occur regularly during plant lifetime.	
1	Several occurrences per year	A frequent event	

The index value assigned to an initiating event may be one value higher or lower than the value. Criteria justifying assignment of the adjusted value should be given in the narrative describing ISA methods. Exceptions require individual justification.

Initiating Event Frequency Indices for all credible High or Intermediate consequence accident scenarios are assigned and documented in Table 1, Column 2.

4.7.3 Identification of IROFS

Applicable IROFS are identified and assigned to all High or Intermediate consequence accident scenarios.

Items Relied On For Safety (IROFS) means structures, systems, equipment, components and activities of personnel that are relied on to prevent potential accidents at a facility that could exceed the performance requirements of 10 CFR 70.61 or to mitigate their potential consequences.

Accordingly, an IROFS provides a safety function that serves to reduce the risk associated with a specific accident scenario. The components of an IROFS function may include operator actions, equipment, control logic, and elements such as time or margin of safety (see example below). In addition, utility subsystems required to maintain the reliability and availability of an IROFS are bounded within the IROFS function. Utilities not required to meet the performance criteria, such as in fail-safe controls or equipment, do not require inclusion in the IROFS functional boundary.

Equipment, actions, or controls within the IROFS functional boundary equipment and sub-systems must be:

- Designed to prevent or mitigate specific, potentially hazardous events. Each identified potential hazard will have corresponding, specific protection strategies.

- Independent so that there is no dependence on components of other protective layers associated with an identified hazard. There must also be no linkage between the initiating event and the ability of the IROFS to perform as required.

- Dependable so that they can be relied on to operate in the prescribed manner. Both random and specific failure modes will be considered in the assessment if there is a probability of protection layers failing on demand or failing during their mission. If human intervention is included as an IROFS, the response time and corresponding human error probability must be considered.

- Auditable in that they are designed to facilitate regular validation (including testing) and maintenance of their protective functions.

Example: an administrative control may require a spill be cleaned up within 8 hours and only if it exceeds 5 gallons (because it is safe if cleaned up in less time or if the volume is below 5 gallons).

Each IROFS is assigned an IROFS Failure Index as specified in Table 4. The Failure Index is defined as the probability that the identified controls will prevent or mitigate the accidental consequence given the initiating event (or set of conditions) occurs. The index is assigned to each IROFS based on industry accepted values, past experience, engineering judgment, analytical data, and/or any other applicable information. The numerical assignments for the IROFS Failure Index are provided in Table 4.

Although the assigned index is qualitative in nature, the "-2" index in Table 4 does correlate to nominal failure probability or rates as published in "Savannah River Site Human Error Data Base Development for Nonreactor Nuclear Facilities." However, the data presented in the Savannah River database does not represent failure rates for IROFS protected by management measures as required in 10 CFR 70, Subpart H. The Savannah River database Administrative Controls are not bounded by the additional scrutiny afforded by assigning the administrative control as an IROFS with management measures to ensure the IROFS is reliable and available to perform its intended function. With such scrutiny, as required by 10 CFR 70, Subpart H, a –2 index is assigned as the index representing an IROFS administrative control in Table 4 (protected by a trained operator performing a routine task with an approved procedure). This value was determined by taking the midpoint of the nominal and high administrative control failure probability or rates from the Savannah River database. Accordingly, a –1 index is assigned for a trained operator performing a non-routine task with an approved procedure.

The Savannah River Site Human Error Date Base Development document is applicable to NFS in that the Savannah River Site provides for operations such as storage, dissolution, and downblending of source terms similar to NFS. In addition, the database is particularly focused to non-reactor nuclear facilities.

Due to the relatively stable source term in the UNB, the administrative controls in Table 1 have been assigned one order of magnitude more conservative. The values in Table 4 are a minimum guide for index assignment, and if applicable, NFS may choose to assign additional conservatism to the indices used in Table 1, thereby assigning additional safety margin to the IROFS.

A special case of accident scenario is when a failure of an IROFS is the initiating event. In these scenarios, an Initiating Event Frequency Index is not assigned. Instead, the IROFS

Failure Index is selected for the IROFS from Table 4. The IROFS that triggers the accident scenario is assigned a Duration Index as specified in Table 5. The Duration Index is a qualitative measurement of the time the system is vulnerable to the failure of a second IROFS when the second IROFS prevents a credible High or Intermediate consequence accident sequence from occurring. As such, the accident sequence is also evaluated by reversing the sequence of failure to determine the system vulnerability based on failing the second IROFS first.

Setpoints for interlocks in active engineered controls or alarms used in administrative controls are determined by engineering analysis that takes into account safety limits, instrument and system accuracy (from vendors), response time, anticipated instrument drift (based on vendor recommendations and operating experience), and other performance factors as appropriate. Setpoints are generally set very conservatively to ensure that the IROFS performance is reliable and making statistical calculations unnecessary. Calibration and functional test frequencies are also determined based on this data. Specifications for procurement of devices used as IROFS take these performance criteria into account and ensure that the device (and the whole IROFS) is reliable and available.

Table 4: IROFS Failure Index

Effectiveness of Protection Index	Type of IROFS**
-4* ***	Protected by an exceptionally robust inspected passive engineered control (PEC). Exceptionally Robust Management Measures to ensure availability.
-3*	Protected by an inspected single PEC or exceptionally robust functionally tested AEC with a trained operator backup. Adequate Management Measures to ensure availability.
-2*	Protected by a single functionally tested AEC. Protected by a trained operator performing a routine task with an approved procedure, an enhanced administrative control, or an administrative control with large margin. Adequate Management Measures to ensure availability.
-1	Protected by a single administrative control or a trained operator performing a non-routine task with an approved procedure.
0	No protection

*Indices less than (more negative than) "-1" should not be assigned to IROFS unless the configuration management, auditing and other management measures are of high quality, because without these measures, the IROFS may be changed or not maintained.

**The index value assigned to an IROFS of a given type may be one value higher or lower than the value given. Criteria justifying assignment of the lower value should be given in the narrative describing ISA methods. Exceptions require individual justification.

***Rarely can be justified by evidence. Further, most types of single IROFS have been observed to fail.

Preventive and Mitigative IROFS Failure Indices for all credible High or Intermediate consequence accident scenarios are assigned and documented in Table 1, Columns 3, 4 and 5.

Table 5: Failure Duration Index Numbers

Duration Index Numbers	Avg. Failure Duration	Duration in Years	Comments
1	More than 3 years	10	
0	1 year	1	
-1	1 month	0.1	Formal Monitoring to justify indices less than "-1)
-2	A few days	0.01	
-3	8 hours	0.001	
-4	1 hour	10^{-4}	
-5	5 minutes	10^{-5}	

Failure Duration Indices for all credible High or Intermediate consequence accident scenarios that result from a failure of an IROFS are assigned and documented in Table 1, Column 3.

4.7.4 Likelihood

To demonstrate compliance with 10 CFR 70.61, all credible accident scenarios upon application of IROFS require a likelihood determination. A Controlled Likelihood and an Uncontrolled Likelihood are calculated to demonstrate the relative importance of the IROFS in preventing or mitigating the accident sequence to meet the performance requirements. A Controlled Likelihood Index T is calculated by summing the Initiating Event Failure Frequency Index to the IROFS Failure Index(s). If the initiating event is an IROFS failure then the Controlled Likelihood Index T is calculated by summing the IROFS Failure Indexes and the Failure Duration Index. An Uncontrolled Likelihood Index T is calculated by using the Initiating Event Failure Frequency Index or the IROFS Failure Index as applicable. Controlled and Uncontrolled Likelihood Categories are then assigned from Table 6 based on the respective Likelihood Index.

Table 6: Total Risk Likelihood Category

Likelihood Category	Likelihood Index T (=sum of index numbers)
1	$T \leq -4$
2	$-4 < T \leq -3$
3	$T > -3$

Controlled and Uncontrolled Likelihood Indices for all credible High or Intermediate consequence accident scenarios are assigned and documented in Table 1, Column 6. Controlled and Uncontrolled Likelihood Categories are assigned and documented in Table 1 Column 7.

4.7.5 Resultant Risk Category

The qualitative values for the Likelihood and Consequence Categories are plotted on the Risk Matrix (Table 7) for categorization of Controlled and Uncontrolled Risk. The Controlled Risk is calculated by multiplying the Consequence Category by the Controlled Likelihood Category. The Uncontrolled Risk is calculated by multiplying the Consequence Category by the Uncontrolled Likelihood Category. 10 CFR 70.61 performance requirement acceptability is determined by comparing the Controlled Risk to Table 7. As shown in Table 7, a risk greater than 4 is unacceptable and does not meet the 10CFR70.61 performance requirements.

Table 7: Risk Matrix

	Likelihood Cat. 1 Highly Unlikely	Likelihood Cat. 2 Unlikely	Likelihood Cat. 3 Not Unlikely
Consequence Cat. 3 High	3 Acceptable	6 Unacceptable	9 Unacceptable
Consequence Cat. 2 Intermediate	2 Acceptable	4 Acceptable	6 Unacceptable
Consequence Cat. 1 Low	1 Acceptable	2 Acceptable	3 Acceptable

Controlled and Uncontrolled Risk for all credible High or Intermediate consequence accident scenarios are assigned and documented in Table 1, Column 9.

4.8 Management Measures for IROFS

Management Measures are applied to IROFS to ensure they are available and reliable to perform their required function when needed, as specified in 10 CFR 70.62(d). The defined set of Management Measures for each IROFS will consist of selected elements of the following management measure programs:

- Configuration Management,
- Maintenance,
- Training and Qualification,
- Procedures,
- Audits and Assessments,
- Incidents and Investigations,
- Records Management, and
- Other Quality Assurance Elements.

The type of IROFS control, along with the risk reduction level credited in the ISA, will determine the level of management measures applied to each IROFS.

The four types of IROFS controls are Active Engineered, Passive Engineered, Administrative, and Enhanced Administrative. The management measures appropriate for each type of control are shown in Table 8.

Not all of the listed management measures would be applied to each IROFS. The management measures applied to a specific IROFS may be graded commensurate with the level of risk reduction credited for the particular IROFS in the ISA. High or Intermediate consequence events depend on IROFS to reduce the overall risk to an acceptable level. High consequence events must be justified as highly unlikely, and Intermediate consequence events justified as unlikely, after implementation of credited IROFS.

Table 8 identifies how management measures are applied in a graded approach based on Risk Reduction levels (Level A or B) credited in the ISA Summary. IROFS credited with a high level of risk reduction (those corresponding to High and/or Intermediate consequence accident sequences (Level A)) will require application of more management measures to ensure a high level of reliability. IROFS credited with a moderate level (those corresponding to Intermediate consequence accident sequences (Level B)) of risk reduction, or intermediate failure likelihood, may have a reduced level of management measures applied. Administrative IROFS that encompass operation of an active component shall require management measure application as specified for enhanced administrative controls to its respective component. **Note that all IROFS in Table 1 for the UNB are considered Level A.**

The applicable management measures identified in Table 8 are applied based on the type of control to ensure that the credited IROFS failure index meets the risk index specified or the design base thresholds for events associated with natural phenomena. Information to justify a deviation from a management measure contained in Table 8 associated with a specific IROFS will be documented.

Table 8 specifies that records management and QA requirements will be adhered to as management measures to ensure the IROFS reliability and availability, and that when demanded the IROFS prevents or mitigates the accident sequence to meet the performance requirements. These management measures will be applied to the design, construction, operations, maintenance and change control of IROFS functional boundaries and identified subsystems. All IROFS boundary equipment and essential utilities will be purchased, inventoried and installed in accordance with engineering design specifications to ensure they are reliable and available to perform their intended function and meet the performance criteria. Management measure Category A IROFS as specified in Table 8 will require functional testing. Documentation of the above steps will be maintained in the ISA files for individual IROFS.

Detailed descriptions of each of the eight management measure program elements can be found in Section 2.12 of SNM-124, "Management Measures for Items Relied on For Safety".

Table 8
Management Measures for IROFS

CONTROL TYPE / Measures	Risk Reduction Level	
	A IROFS credited with a high level of Risk Reduction for High or Intermediate consequence events	B IROFS credited with a moderate level of Risk Reduction for Intermediate consequence events
ACTIVE ENGINEERED CONTROLS		
Periodic Functional Test	x	
Maintenance	x	
Verification After Maintenance	x	
Calibration	x	x
Controlled Listing Identification	x	
Drawing Identification	x	
Procedural Identification	x	x
Pre-operational Audits or Tests	x	x
Periodic Audits	x	x
Training and Qualifications	x	
Records Management, Investigations, and other quality assurance elements	x	
PASSIVE ENGINEERED CONTROLS		
Maintenance	x	
Verification After Maintenance	x	
Controlled Listing Identification	x	
Procedural Identification	x	x
Pre-operational Audits or Tests	x	x
Independent Installation Verification	x	
Periodic Audits or Inspections	x	x
Vendor Specifications	x	
Training and Qualifications	x	
Records Management, Investigations, and other quality assurance elements	x	
ADMINISTRATIVE CONTROLS		
Procedural or Posting Identification	x	x
Pre-operational Audits	x	x
Periodic Audits	x	x
Training and Qualification	x	
Testing of Training Effectiveness	x	
Records Management, Investigations, and other quality assurance elements	x	
ENHANCED ADMINISTRATIVE CONTROLS		
Periodic Functional Test	x	
Maintenance	x	
Verification After Maintenance	x	
Calibration	x	x
Controlled Listing Identification	x	x
Drawing Identification	x	x
Procedural or Posting Identification	x	x
Pre-operational Audits	x	x
Periodic Audits	x	x
Training and Qualification	x	
Testing of Training Effectiveness	x	
Records Management, Investigations, and other quality assurance elements	x	

Note: The Management Measures identified for each risk reduction level are minimum if applicable. For example, it is not possible to calibrate certain types of active engineered controls. The controls may be increased based on the specific IROFS involved, the credited risk reduction, industry standards, vendor specifications, or engineering recommendations.

5.0 ISA Team

The ISA Team for the BLEU UNB consisted of personnel from both Framatome-ANP and Nuclear Fuel Services. The list of team members follows:

- Kirk D. Barlow, Sr. Chemical Engineer, FRA-ANP, Team Leader

  ISA Leader training by the Process Safety Institute, Knoxville, TN, July 23-25, 2001

  Hazard & Operability (HAZOP) Studies for Process Safety & Risk Management training by the American Institute of Chemical Engineers, Raleigh, NC, July 22-24, 1998.

- Jeffrey M. Deist, Criticality Safety Specialist, FRA-ANP
- John J. Korenkiewicz, Technician, Chemical Operations, FRA-ANP
- Steve R. Lockhaven, Industrial Hygienist, FRA-ANP
- James H. Parker, Manager, Industrial Safety (Fire Protection), NFS
- L. Randy Sanders, Licensing Specialist, CHP, NFS
- David Hopson, Nuclear Criticality Safety Engineer, NFS
- Gail Tapp, Industrial Safety Specialist, NFS
- Brian Gleckler, Health Physicist, NFS
- Allen Cure, Health Physicist, NFS
- Sonya Sanders, Health Physicist, NFS
- Jimmy Napier, Environmental Scientist, NFS
- Joseph Chew, Industrial Safety Specialist, NFS
- Richard Montgomery, Nuclear Criticality Safety Engineer, NFS
- Clifford J. Yeager, P.E., Process and I&C Engineer, FRA-ANP
- Charles F. Holman, Process Engineer, FRA-ANP

6.0 List of IROFS for the UNB Facility

Table 9 lists and provides details about the IROFS referenced in Table 1 above. Refer to Table 8 for management measures corresponding to the Type and Risk Reduction Level (RRL) for each IROFS.

Table 9: Items Relied On For Safety (IROFS)

IROFS ID #	Description	Type	Failure Index	Failure Description	RRL
UNB-A		Active Engineered Control	-2		A
UNB-B		Active Engineered Control	-2		A
UNB-C		Administrative Control	-1		A
UNB-D		Passive Engineered Control	-3		A
UNB-E		Passive Engineered Control	-3		A
UNB-F		Passive Engineered Control	-3		A
UNB-G		Enhanced Administrative Control	-1		A
UNB-H		Active Engineered Control	-2		A

IROFS ID #	Description	Type	Failure Index	Failure Description	RRL
UNB-I		Passive Engineered Control	-3		A
UNB-J		Enhanced Administrative Control	-1		A
UNB-K		Administrative Control	-1		A
UNB-L		Active Engineered Control	-2		A
UNB-M		Active Engineered Control	-2		A
UNB-N		Passive Engineered Control	-3		A
UNB-O		Passive Engineered Control	-3		A
UNB-P		Passive Engineered Control	-3		A
UNB-Q		Active Engineered Control	-2		A
UNB-R		Administrative Control	-1		A
UNB-S		Active Engineered Control	-2		A

IROFS ID #	Description	Type	Failure Index	Failure Description	RRL
UNB-T		Active Engineered Control	-2		A
UNB-U		Passive Engineered Control	-2		A
UNB-V		Active Engineered Control	-2		A
UNB-W		Administrative Control	-1		A
UNB-X		Passive engineered control			A
UNB-Y		Passive engineered control			A
UNB-Z		Passive engineered control			A

7.0 Chemical Consequence Standards

AEGLs, PELCs, TEELs, or IDLH values are utilized as justified when ERPG values do not exist. Nitric Oxide (NO) ERPG action levels do not exist. Therefore, the following NO Action level justification is provided:

Selection of (NO) Action levels:
Chemical exposure to the offsite population was considered in this evaluation. Since no emergency response planning guides exist for nitric oxide (NO), temporary emergency exposure limits (TEELs) developed by the Department of Energy (DOE) Subcommittee on Consequence Assessment & Protective Actions (SCAPA) were adopted as comparative action levels. TEELs are approximations of ERPG level 1, 2 and 3 values. The TEEL-1 and 2 values for NO are 25 ppm. The TEEL-3 value for NO is 100 ppm. These values were obtained from TEELs revision 17 available at www.bnl.gov/scapa/.

8.0 Sole IROFS in the UNB Facility

There are no "sole IROFS" used for this facility.

9.0 Definitions

Highly Unlikely – Physically possible or credible, but not expected to occur. A Credible Accident Scenario/Sequence, that is based upon a graded combination of IROFS such as Active Engineering Controls (AEC), Passive Engineering Controls (PEC) and Administrative Controls that mitigate or prevent the accident from occurring such that a Qualitative Likelihood Category 1 (per Table 6) or a quantifiable probability of less than an index of -4 exists. For nuclear criticality safety purposes, a system that possesses Double Contingency protection is considered Highly Unlikely, provided that the performance requirements specified in 10 CFR 70.61 are fulfilled.

Unlikely – Not expected to occur during the plant lifetime. A Credible Accident Scenario/Sequence that is based upon a graded combination of IROFS such as Active Engineering Controls (AEC), Passive Engineering Controls (PEC) and Administrative Controls that mitigate or prevent the accident from occurring such that a Qualitative Likelihood Category 1 or 2 (per Table 6) or a quantifiable probability of less than an index of -3 exists.

Not Unlikely – Credible Accident Scenarios that are not Unlikely or not Highly Unlikely (Category 3 below). Although this category includes unintended events that might actually be expected to happen, others might be less frequent. For this reason, the term "likely" was not used for these events.

Baseline Design Natural Phenomena Event – A physically credible natural phenomena event not expected to occur during plant lifetime that has the capability to exceed the performance criteria specified in 10 CFR 70.61. Protection is afforded by designing and constructing a facility to applicable sections of the Standard Building Code and by ensuring operational adherence to this code through a configuration management change control process. Adherence to 10 CFR 62(c)(iv) and 10 CFR 70.64(a)(2) is demonstrated by eliminating potential high or intermediate

consequences through baseline design thresholds applied to establish a defined protection envelope for each type of natural phenomena event.

10.0 References

1. *Guidelines for Hazard Evaluation Procedures*, 2nd ed., Center for Chemical Process Safety, AIChE, New York, 1992.

2. 29 CFR 1910.119, *Process Safety Management of Highly Hazardous Chemicals*, Occupational Safety and Health Administration, Washington, DC, 1992.

3. *Layer of Protection Analysis – Simplified Risk Assessment*, Center for Chemical Process Safety, AIChE, New York, 2001.

4. 10 CFR Part 70, *Domestic Licensing of Special Nuclear Material*, U.S. Nuclear Regulatory Commission, Washington, DC, September 2000.

5. A. D. Swain and H. E. Guttman, *Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications*, NUREG/CR-1278, U.S. Nuclear Regulatory Commission, Washington, DC, August 1983.

6. *Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility (DRAFT)*, NUREG-1520, U.S. Nuclear Regulatory Commission, Washington, DC, June 1999.

7. R.L. Milstein, *Integrated Safety Analysis Guidance Document*, NUREG-1513, U.S. Nuclear Regulatory Commission, Washington, DC, May 2001.

8. *Nuclear Fuel Cycle Facility Accident Analysis Handbook*, NUREG/CR-6410, U.S. Nuclear Regulatory Commission, Washington, DC, March 1998.

9. *Fire Hazard Analysis BLEU Uranyl Nitrate Building (UNB)*, William H. Julius, P.E. Revision 7, May 20, 2003.

10. *BLEU Project Process Hazards Analysis; Uranyl Nitrate Building (UNB)*, K. D. Barlow, 54T-02-006, NCS-07-02, Revision 1. July 2002.

11. *Nuclear Criticality Safety Evaluation for the BLEU Complex Uranyl Nitrate Building*, R. D. Montgomery, 54T-03-0022, NCS-07-02, Revision 3. May 2003.

Appendix A: BASELINE DESIGN CRITERIA FOR BLEU COMPLEX UNB FACILITY

The following information is provided to demonstrate that the Baseline Design Criteria of 10 CFR 70.64, "Requirements for New Facilities or New Processes at Existing Facilities" have been addressed in the design of UNB. Each of the ten sections of 10 CFR 70.64(a) "*Baseline Design Criteria*," as well as the "*defense-in-depth*" sections of 10 CFR 70.64(b), are addressed below.

(a) Baseline Design Criteria

(1) Quality Standards & Records: *The design must be developed and implemented in accordance with management measures, to provide adequate assurance that IROFS will be available and reliable to perform their function when needed. Appropriate records of these items must be maintained by or under the control of the licensee throughout the life of the facility.*

As stated, 10 CFR 70.64(a)(1) requires the use of appropriate management measures to assure the availability and reliability of items relied on for safety. The management measures listed in Section 4.8 of the UNB ISA Summary have been programmatically used by NFS since 1996 to successfully maintain items relied on for safety. The successful implementation of this management measure program is verified by NFS through regularly scheduled internal quality assurance audits and has been rigorously scrutinized by the NRC since its inception. As required by the latter part of 70.64(a)(1), appropriate program records have been and will continue to be maintained by NFS. Concerning materials and equipment specifications, NFS defines and confirms upon procurement the applicable design specifications prior to materials and equipment use. When standard off-the-shelf components are identified as items relied on for safety, the appropriate management measures (e.g. functional testing, inspections, calibration) are implemented to assure their availability and reliability.

Functional testing of IROFS is scheduled, performed, tracked, and documented for review per NFS' Safety Related Equipment Program. Functional testing is performed to ensure that the IROFS is reliable and available to perform its intended safety function. Functional testing is conducted using approved procedures with process compensatory measures being applied while the test is being performed. The functional testing periodicity is established by risk assessment and operational safety discipline evaluations.

(2) Natural Phenomena Hazards: *The design must provide for adequate protection against natural phenomena with consideration of the most severe documented historical events for the site.*

Natural phenomena are discussed in detail in Section 1 of the Summary. Baseline Design Natural Phenomena Events as defined in Section 9.0 have design thresholds applied to establish a defined protection envelope to prevent unsafe conditions arising from natural phenomena events. The UNB baseline design threshold for each natural phenomena event is as follows:

Seismic	The UNB facility is designed and constructed to seismic zone IIC criteria as specified in Section 1607 of the 1999 Standard Building Code and is equipped with a tank restraint system designed to withstand a 0.1 g horizontal and vertical ground acceleration. The threshold return period for which the facility is designed and constructed to is 2E-3/yr. The Effective Peak Velocity Related Acceleration Coefficient *Av* and Peak Acceleration Coefficient *Aa* are defined as specified in Figures 1607.1.5A and 1607.1.5B of the Code respectively. Facility IROFS are assigned to prevent a high consequence event that may result from a seismic event within the specified threshold envelope. Refer to Table 9 for IROFS UNB-X and UNB-Y descriptions.
High Winds	The UNB facility is designed and constructed to withstand basic sustained wind speeds up to 70 miles per hour as specified in Section 1606 of the 1999 Standard Building Code. Facility IROFS are assigned to prevent a high consequence event that may result from high winds within the specified threshold envelope. Refer to Table 9 for IROFS UNB-Z description.
Flooding	The UNB facility is located above the 100-year flood plain base flood elevation threshold. As such, there is no physically credible accident scenario that could result in a flood of the facility.
Lightning	Lightning protection is installed in the UNB facility per the applicable portions of NFPA 780. There are no credible UNB accident scenarios that result in an intermediate or high consequence event as a result of a lightning strike.
Tornado	There are no credible accident scenarios that result in an intermediate or high consequence event as a result of a direct tornado strike on the UNB facility.

Code compliance in these cases is ensured by:

- Design drawings and specifications call out applicable code requirements.
- Suppliers and vendors certify that supplied equipment and systems comply with the drawings and specifications, and other relevant codes. For instance, the building supplier provides certification that the building structure was designed to the Standard Building Code (SBC).
- Construction/installation per the design specifications by qualified contractors. For example, the building was constructed by trained construction personnel; the construction contractor has many years of experience with industrial and commercial construction projects; and the contractor has provided certification that the building was constructed per the design.
- Construction progress was reviewed frequently by qualified Framatome ANP engineering personnel.

- Multiple inspections were performed by the Town of Erwin inspectors as part of the Building Permit process (plumbing, electrical, building, etc.). A Certificate of Occupancy was issued when the last inspection was completed satisfactorily.
- The internal Acceptance Test Procedures have signoff/checklists that document the as-built verifications that the various installations meet code requirements, where applicable.
- Walkdowns of the facility were conducted as part of the internal Operational Readiness Review process to ensure the building construction and equipment installation was completed properly.
- Any future change to the facility, structures, processes, systems, equipment, components, computer programs, procedures, etc. shall be evaluated per License Condition S-25 criteria. The change will be reviewed against the approved safety bases, to include the Standard Building Code and other applicable codes.

(3) Fire Protection: *The design must provide for adequate protection against fires and explosions.*

The UNB facility has a full-featured fire detection and suppression system. Fire hazards are evaluated in a Fire Hazard Analysis (Reference 9), and the FHA provides the design basis assumptions for adequate overall fire protection for the UNB facility. Fire accident scenario A in Table 1 requires the use of IROFS UNB-V from Table 9 to prevent and mitigate the accident sequence to meet the 10 CFR 70.61 performance criteria. This IROFS consists of a full-featured fire detection and suppression system as specified in NFPA 72, NFPA 25, NFPA 13, and Reference 9.

(4) Environmental & Dynamic Effects: *The design must provide for adequate protection from environmental conditions and dynamic effects associated with normal operations, maintenance, testing, and postulated accidents that could lead to loss of safety functions.*

The UNB facility is designed to minimize problems from variations (both normal and from credible upsets) in the ambient and process conditions under which the IROFS equipment is expected to operate. Consideration in the design of the facility and equipment was given to the following to prevent loss of safety functions:

- Protection of piping and vessels from vehicles and forklifts.
- Protection of fittings from external impact.
- Corrosion protection.
- Vibration from pumps/fans etc.
- Water discharge from sprinkler systems (or other splash).
- Weather
- Other facility siting factors including the railway, air traffic patterns, and nearby commercial facilities.

As such, IROFS are qualified to demonstrate that they can perform their safety functions under the environmental and dynamic service conditions in which they will be required to function and for the length of time their function is required.

Specific requirements for each IROFS are contained in the ISA.

(5) Chemical Protection: *The design must provide for adequate protection against chemical risks produced from licensed material, facility conditions which affect the safety of licensed material, and hazardous chemicals produced from license material.*

The only chemicals used in the UNB are DIW and UN solution (which contains < 1M nitric acid). Chemical safety is achieved through administrative as well as passive and active engineered controls. The proper handling, use, and storage of chemicals is addressed through procedures and Hazard Communication training. The ISA has evaluated any scenarios that could result in hazardous chemicals contacting or resulting in the dispersion of licensed material.

(6) Emergency Capability: *The design must provide for emergency capability to maintain control of:*

i. Licensed material and hazardous chemicals produced from licensed material.
ii. Evacuation of on-site personnel.
iii. On-site emergency facilities and services that facilitate the use of available offsite services.

(i) Licensed material and hazardous chemicals produced from licensed material;

The design basis for the planned measures at the BLEU Complex, which will control access to licensed material and hazardous chemicals produced from licensed materials are:

1. NRC Category III security requirements. These requirements are described in Chapter 2 of NFS' security plan, NFS-SEC-C3-PSP.

2. An evacuation system in accordance with applicable sections of ANSI Standard 8.23, *Nuclear Criticality Accident Emergency Planning and Response.*

3. An Emergency Response organization in accordance with ANSI Standard 8.23, *Nuclear Criticality Accident Emergency Planning and Response.*

4. A chain of command system similar to the Incident Command System used by FEMA and all major response organizations.

A system established in accordance with ANSI Standard 8.23, *Nuclear Criticality Accident Emergency Planning and Response*, provides measures to control potential exposure to licensed material and hazardous chemicals at the BLEU Complex. The specific item in the standard is "*Sufficient exits from the immediate evacuation zone which provide rapid and unobstructed evacuation of personnel.*" The number of exits in the UNB meet the requirements of the Life Safety Code.

The ERO system as described in Chapter 4 of the Emergency Plan reduces the risk of potential exposure to on-site and off-site emergency responders. The ERO System follows a chain of command structure. The Emergency Control Director (ECD) with the support of Emergency Response Organization members who have the necessary training and expertise, directs all emergency response measures, including approval for off-site agency personnel and vehicles (e.g., Fire Department and Ambulance Service) to enter the facility.

(ii) Evacuation of on-site personnel;

The design basis for the items addressed in the Emergency Plan to ensure control of the evacuation of on-site personnel is:

1. A criticality detection system in accordance with requirements of 10 CFR 70.24.
2. An evacuation system, in accordance with ANSI Standard 8.23, *Nuclear Criticality Accident Emergency Planning and Response* including the following elements:
    a. Timely evacuation. When an evacuation is initiated all personnel within the immediate evacuation zone shall evacuate without hesitation by planned evacuation routes to an established assembly area.
    b. Equipment and personnel are available for radiological assessment of the assembly location and evacuated personnel.
    c. Sufficient exits from the immediate evacuation zone are provided to enable rapid and unobstructed evacuation of personnel.
    d. Evacuation route and assembly area are clearly posted.
    e. Evacuation route minimizes the total risk considering all potential hazards.
3. A dose level for determination of a safe evacuation assembly area based on ANSI Standard 8.3, Criticality Accident Alarm System and its definition for an excessive radiation dose as 12 rad.
4. An assembly area accessible by emergency agencies for triage and transport of victims.

(iii) Onsite emergency facilities and services that facilitate the use of available offsite services.

The design basis for the items addressed in the NFS Emergency Plan to ensure control of the onsite emergency facilities and services that facilitate the use of available offsite services is found in applicable sections of ANSI Standard 8.23, *Nuclear Criticality Accident Emergency Planning and Response*. The elements include the following;

1. An Emergency Response Organization and support teams with appropriate expertise and experience. Regular training and exercises provided to the team members.

2. The emergency facilities, which support the BLEU Complex, located outside the immediate evacuation zone.
3. Appropriate monitoring equipment, emergency response documents, and protective clothing/equipment housed in the emergency facilities.
4. Contents of the emergency facilities inspected on a regular frequency.
5. Letters of agreement for support by off-site agencies.
6. Training and orientation to off-site agencies occurring on an annual basis.
7. An emergency message information system for timely notification to off-site agencies established.

The design basis for our selection of our offsite Emergency Facilities is as follows:

1. Timely response
    a. The performance of the Erwin Fire Department to area fires indicates that they can respond in less than 10 minutes.
    b. Unicoi County Hospital is located five minutes away
    c. Johnson City Medical Center is located approximately 20 minutes by ambulance and less than 15 minutes by air transport
2. Sufficient trained personnel
    a. Our primary Fire-Fighting agency is the Erwin Fire Department who routinely sees response of about 15 persons to a fire event. The agency has cooperative agreements with nearby county agencies (volunteer and paid) for further support.
    b. Quality Care Ambulance Service- The agency has two ambulances with available additional resources from neighboring counties and states. Quality Care works with Wings Air Rescue for air transports. The neighboring counties and states would be able to respond in 30 to 45 minutes. The agency has a dispatch system for acquiring sufficient support.
3. Hospital with Level One Trauma Center Capabilities
    a. Johnson City Medical Center is rated as a Trauma One Center. Oak Ridge's Radiation Emergency Assistance Center Training Site (REAC/TS) has reviewed JCMC capabilities and has stated that they would be an appropriate hospital for victims of criticality and radiation accidents.
4. Hospitals equipped for radioactive contaminated persons
    a. Both JCMC and the local hospital, Unicoi County Hospital has a program, trained staff and equipment to respond to a radiation accident.

(7) Utility Services: *The design must provide continued operation of essential utility services. The new process is designed to be compatible with existing utility services.*

There is only one utility in the UNB that could be considered an "essential utility service" – the water supply to the fire suppression system. The "continued operation" of this system is assured because the water supply meets all relevant NFPA requirements for

such a system. To enhance the reliability of the water supply for the sprinkler system, the water supply pressure to the fire suppression system will be monitored and will alarm in the CCS if the pressure drops below sprinkler system design requirements. In the event that pressure is lost, impairment procedures will be activated.

All other utilities, whether supplied from offsite (electricity, natural gas, etc.) or generated onsite (compressed air, DIW, etc.) are not considered "essential". Systems such as the fire alarm system and criticality monitors have dedicated sources of emergency power in the event power is lost. Accident scenarios related to the loss of primary and backup power and the effects on other service utilities have been evaluated. Further, the effect of loss of power on the effectiveness of IROFS was evaluated. No unsafe conditions were identified resulting from loss of power. The entire facility is designed fail safe so that loss of power causes control devices to fail into a safe state. An exception is the building temperature control system, which is only a safety consideration in extremely cold, extremely long power outage situations, which are highly unlikely to occur. Finally, fire detection systems, criticality monitors/alarms, and building evacuation alarms are located in areas where they should not be susceptible to damage.

(8) Inspection, Testing & Maintenance: *The design of IROFS must provide for adequate inspection, testing and maintenance, to ensure their availability and reliability to perform their function when needed.*

See Section 4.8 of the ISA Summary for a discussion of IROFS selection and maintenance.

(9) Criticality Control: *The design must provide for criticality control including adherence to the double contingency principle.*

All SNM operations in the UNB are designed with sufficient factors of safety to require at least two unlikely, independent and concurrent changes in process conditions before a criticality accident is possible. This concept is known as the "double contingency principle." Whenever practicable, the effectiveness of the controls will be enhanced through diversity and redundancy of reliable barriers, and defense in depth.
Any changes to the criticality monitoring system are administered via the change management system referenced in Section 4.8. Criticality controls and Defense in Depth are evaluated for the UNB in the Nuclear Criticality Safety Evaluation (NCSE), Reference 11.

(10) Instrumentation & Controls: *The design must provide for inclusion of instrumentation and control systems to monitor and control the behavior of IROFS.*

Active engineered controls are used extensively for safety purposes in the UNB facility. Section 4.8 of the ISA Summary addresses the requirements for inspection, periodic functional checks, and maintenance to ensure the effectiveness of IROFS. This type of IROFS is typically implemented through the Central Control System (CCS). The CCS provides extensive internal diagnostic checks that will detect component failures and trigger alarms and in appropriate cases will send the outputs to a safe state. This is true

for individual field instruments up through the controllers themselves and all communication links in between.

In general, equipment systems that will be used as enhanced administrative or active engineered control IROFS will have means for verification that key components of the IROFS are functional. Applicable information about monitoring each individual IROFS of these types will be contained in the ISA.

(b) Facility and system design and facility layout must be based on defense-in-depth practices.

(1) *Preference for the selection of engineered controls over administrative controls to increase overall system reliability.*

Per the risk-based ISA process, as defined in NUREG-1520, risks are minimized by selecting the appropriate level of controls that will render each accident scenario that has a high consequence "highly unlikely". However, in general the following is the listed order of preference:

1. Passive Engineered Control (most preferred)
2. Active Engineered Control
3. Enhanced Administered Control
4. Administrative Control (least preferred)

When used, administrative controls are appropriately enhanced through the use of postings, procedures, and computer programs that act as aids for the operator. In addition, appropriate safety margins are provided for administrative controls.

(2) *Features that enhance safety by reducing challenges to items relied on for safety.*

The design of the UNB includes many features than enhance the safety of the process. Because of this, and because of the benign nature of the UNB operations, no scenarios have been identified in which the IROFS are challenged frequently.

Appendix B. Natural Phenomena, Fire, and External Event Scenarios Table

Scenario #	*Initiating Events*	*Unmitigated Consequence*	*Controls/Mitigating Factors*
1	Earthquake	Potential to rupture multiple tanks in the UNB, causing radiological contamination extending outside of the building.	UNB and UN storage tank restraint system are designed to meet or exceed 1999 SBC Zone IIC seismic requirements (0.1g horizontal acceleration). NFS seismic analysis determined that for a 1,000 year return period, the horizontal acceleration is 0.06 g. Small falling objects (i. e. pipe, light fixtures, pieces of metal siding, etc.) will not cause catastrophic failure of tanks. The probability of earthquake damage severe enough to cause failure of major structural components of the building and subsequent catastrophic damage to multiple tanks is Low. An evaluation of damage after a 1994 earthquake in California with horizontal acceleration of 0.5 g showed properly anchored FRP tanks were undamaged. The probability of earthquake damage severe enough to cause failure of multiple tanks in a manner that would allow the total contents to spill is Low. No criticality issues due to concentration control. No short-term mechanism to concentrate solution.
2	Storm - High Winds	Potential for building damage and subsequent rupture of multiple tanks in the UNB, causing radiological contamination extending outside of the building.	UNB is designed to withstand 80 mph wind in accordance with the Standard Building Code. NOAA data collected at the regional airport indicates maximum sustained wind of 50 mph (recorded in 1951) and a peak gust of 86 mph (recorded in 1995). Small objects striking tanks at or near the top will not cause damage that would allow the total contents of the tank to spill. The probability of wind damage severe enough to cause failure of major structural components of the building and subsequent catastrophic damage to multiple tanks is Low. No criticality issues due to concentration control. No short-term mechanism to concentrate solution.

Scenario #	Initiating Events	Unmitigated Consequence	Controls/Mitigating Factors
3	Tornado	Potential for building damage and subsequent rupture of multiple tanks in the UNB, causing radiological contamination extending outside of the building.	UNB is designed in accordance with the Southern Building Code. One tornado recorded in county since 1950. Tornadoes travel in narrow irregular paths tending to strike higher terrain rather than valleys. Likelihood of a tornado striking UNB is Low. Small falling objects striking tanks at or near the top will not cause damage that would allow the total contents of the tank to spill. The probability of tornado damage severe enough to cause failure of major structural components of the building and subsequent catastrophic damage to multiple tanks is Low. No criticality issues due to concentration control. No short-term mechanism to concentrate solution.
4	Hurricane	Potential for building damage and subsequent rupture of multiple tanks in the UNB, causing radiological contamination extending outside of the building.	Plant location is too far inland to be considered a credible risk due to hurricane. No criticality issues due to concentration control. No short-term mechanism to concentrate solution.
5	Flood	Potential to rupture multiple UN storage tanks causing radiological contamination extending outside of the building.	Plant location is above the 100 year flood level of all nearby rivers and streams (100 year flood plain of Martin Creek is 1640 feet, floor of UNB is 1655 feet). No criticality issues due to concentration control. No short-term mechanism to concentrate solution.
6	Site evacuation with operators leaving stations prior to shut down	Deviations from designed process that could occur due to operator error or absence and which may result in an accident scenario with significant consequence.	HAZOPS analysis (summary table in Section 13.0) verifies that the process design includes passive and/or engineered fail-safe controls to protect against potentially hazardous deviations in case of operator absence.

Scenario #	Initiating Events	Unmitigated Consequence	Controls/Mitigating Factors
7	NFS bulk chemical storage accident resulting in release of bulk liquid and evaporated chemicals.	Material concerns - material interactions from corrosive, oxidative, reactive, or flammable chemicals. Chemical concerns - reactivity with UNB process equipment or with UN solutions causing criticality accident. Personnel concerns - release of chemicals that may be toxic, flammable, explosive, asphyxiant, or other health hazard for on site personnel.	Bulk chemical storage area located inside NFS fence is > 400 feet from UNB. Bulk liquids will be contained within NFS facilities. Site is graded for drainage - no significant bulk liquid will flow across open, graded ground to UNB. No credible interaction with process equipment or UN solutions for following reasons: 1) Only dilute vapors will reach UNB. Limited by plume concentration, diffusion rate, distance, atmospheric conditions. 2) Building protected by ventilation system. Storage tanks are sealed. Building evacuation plan in unlikely case that threatens on site personnel (see scenario #6 for operator evacuation).
8	NFS bulk chemical storage accident resulting in release of bulk vapor.	Material concerns - material interactions from corrosive, oxidative, reactive, or flammable chemicals. Chemical concerns - reactivity with UNB process equipment or with UN solutions causing criticality accident. Personnel concerns - release of chemicals that may be toxic, flammable, explosive, asphyxiant, or other health hazard for on site personnel.	Bulk chemical storage area located inside NFS fence is > 400 feet from UNB. No credible interaction with process equipment or UN solutions for following reasons: 1) Only dilute vapors will reach UNB. Limited by plume concentration, diffusion rate, distance, atmospheric conditions. 2) Building protected by ventilation system. Storage tanks are sealed. Building evacuation plan in unlikely case that threatens on site personnel (see scenario #6 for operator evacuation).

Scenario #	Initiating Events	Unmitigated Consequence	Controls/Mitigating Factors
9	NFS bulk chemical storage accident resulting in explosion or fire (most likely bounded by scenarios involving hydrogen storage vessels)	Potential off-site fire that could spread to UNB	Bulk chemical storage area located inside NFS fence is [redacted] Site will be maintained to provide at least a 50' fire break. UNB constructed of non-combustible materials. UNB design includes fire walls and fire sprinklers in accordance with NFPA code. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade. Building evacuation plan in unlikely case that threatens on site personnel (see scenario #6 for operator evacuation).
10	NFS criticality accident or radiological release	Potential exposure for on site workers causing evacuation of site.	NFS controls and operating procedures. Emergency evacuation plan in unlikely case that threatens on site personnel (see scenario #6 for operator evacuation).
11	Studsvik bulk chemical storage accident resulting in release of bulk liquid and evaporated chemicals.	Material concerns - material interactions from corrosive, oxidative, reactive, or flammable chemicals. Chemical concerns - reactivity with UNB process equipment or with UN solutions causing criticality accident. Personnel concerns - release of chemicals that may be toxic, flammable, explosive, asphyxiant, or other health hazard for on site personnel.	Bulk chemical storage area located inside [redacted] Bulk liquids will be contained within Studsvik facilities. Site is graded for drainage - no significant bulk liquid will flow across open, graded ground to UNB. No credible interaction with process equipment or UN solutions for following reasons: 1) Only dilute vapors will reach UNB. Limited by plume concentration, diffusion rate, distance, atmospheric conditions. 2) Building protected by ventilation system. Storage tanks are sealed. Building evacuation plan in unlikely case that threatens on site personnel (see scenario #6 for operator evacuation).

Scenario #	Initiating Events	Unmitigated Consequence	Controls/Mitigating Factors
12	Studsvik bulk chemical storage accident resulting in release of bulk vapor.	Material concerns - material interactions from corrosive, oxidative, reactive, or flammable chemicals. Chemical concerns - reactivity with UNB process equipment or with UN solutions causing criticality accident. Personnel concerns - release of chemicals that may be toxic, flammable, explosive, asphyxiant, or other health hazard for on site personnel.	Bulk chemical storage area located inside Studsvik fence is >[redacted] No credible interaction with process equipment or UN solutions for following reasons: 1) Only dilute vapors will reach UNB. Limited by plume concentration, diffusion rate, distance, atmospheric conditions. 2) Building protected by ventilation system. Storage tanks are sealed. Building evacuation plan in unlikely case that threatens on site personnel (see scenario #6 for operator evacuation).
13	Studsvik bulk chemical storage accident resulting in explosion or fire	Potential off-site fire that could spread to UNB	Bulk chemical storage area located inside Studsvik fence is[redacted] Site will be maintained to provide at least a 50' fire break. UNB constructed of non-combustible materials. UNB design includes fire walls and fire sprinklers in accordance with NFPA code. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade. Building evacuation plan in unlikely case that threatens on site personnel (see scenario #6 for operator evacuation).

Scenario #	Initiating Events	Unmitigated Consequence	Controls/Mitigating Factors
14	Studsvik radiological release	Potential exposure for on site workers causing evacuation of site.	Low inventory of radioactive material. Studsvik controls and operating procedures. Emergency evacuation plan in unlikely case that threatens on site personnel (see scenario #6 for operator evacuation).
15	Railroad Accident Causing Explosion or Fire	Off-site explosion and fire that spreads to UNB.	Railroad is ~220 feet NW of the UNB. Speed limit in rail yard is 10 mph. Site will be maintained to provide at least a 50' fire break. UNB constructed of non-combustible materials. UNB design includes fire walls and fire sprinklers in accordance with NFPA code. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade. Building evacuation plan in unlikely case that threatens on site personnel (see scenario #6 for operator evacuation).

Scenario #	Initiating Events	Unmitigated Consequence	Controls/Mitigating Factors
16	Railroad accident causing release of bulk liquid and evaporated chemicals	Material concerns - material interactions from corrosive, oxidative, reactive, or flammable chemicals. Chemical concerns - reactivity with UNB process equipment or with UN solutions causing criticality accident. Personnel concerns - release of chemicals that may be toxic, flammable, explosive, asphyxiant, or other health hazard for on site personnel.	Railroad is ~220 feet NW of the UNB. Speed limit in rail yard is 10 mph. Bulk liquids will be contained within rail yard. Site is graded for drainage - no significant bulk liquid will flow across open, graded ground to UNB. No credible interaction with process equipment or UN solutions for following reasons: 1) Only dilute vapors will reach UNB. Limited by plume concentration, diffusion rate, distance, atmospheric conditions. 2) Building protected by ventilation system. Storage tanks are sealed. Building evacuation plan in unlikely case that threatens on site personnel (see scenario #6 for operator evacuation).
17	Railroad accident causing release of bulk vapor	Material concerns - material interactions from corrosive, oxidative, reactive, or flammable chemicals. Chemical concerns - reactivity with UNB process equipment or with UN solutions causing criticality accident. Personnel concerns - release of chemicals that may be toxic, flammable, explosive, asphyxiant, or other health hazard for on site personnel.	Railroad is ~220 feet NW of the UNB. Speed limit in rail yard is 10 mph. No credible interaction with process equipment or UN solutions for following reasons: 1) Only dilute vapors will reach UNB. Limited by plume concentration, diffusion rate, distance, atmospheric conditions. 2) Building protected by ventilation system. Storage tanks are sealed. Building evacuation plan in unlikely case that threatens on site personnel (see scenario #6 for operator evacuation).

Scenario #	Initiating Events	Unmitigated Consequence	Controls/Mitigating Factors
18	Plane Crash	Possible destruction of UNB due to impact and/or fire Plane does not impact UNB but fire starts and spreads to UNB	UNB not in any landing or takeoff pattern of any airport. Nearest public airport is 40 miles away. Probability of large aircraft striking UNB is Highly Unlikely. Nearest private airport for small planes is in Washington County. Other landing strips nearby are for ultralight aircraft only. Probability of small aircraft striking UNB and causing severe enough damage to result in catastrophic failure of multiple tanks is Highly Unlikely. Site will be maintained to provide at least a 50' fire break. UNB constructed of non-combustible materials. UNB design includes fire walls and fire sprinklers in accordance with NFPA code. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade.
19	Freeway Traffic Accident	Structural damage to UNB due to impact and/or fire Accident causes an off-site fire that spreads to UNB	UNB located far from freeway and other roads. Closest road, Carolina Avenue is ~500 feet from UNB. Probability of vehicle striking UNB and causing severe enough damage to result in catastrophic failure of multiple tanks is Highly Unlikely. Site will be maintained to provide at least a 50' fire break. UNB constructed of non-combustible materials. UNB design includes fire walls and fire sprinklers in accordance with NFPA code. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade.
20	Others - Meteorites, etc..	Destruction of UNB	meteorites etc. = Highly Unlikely.

Scenario #	Initiating Events	Unmitigated Consequence	Controls/Mitigating Factors
21	Diesel fire at Standby Generator	Moderate fire damaging emergency generator equipment - Fire spreads to UNB	Designed and installed in accordance with NFPA 70 & 110. Generator is UL 2200 compliant with non-combustible enclosure. Generator will be [redacted] from UNB which exceeds requirement of NFPA 37. NFPA 37 requires stationary combustion engines and enclosures to be located 5" from structures having combustible walls. UNB constructed of non-combustible materials. Although not required by NFPA 37 or 110, the generator enclosure will have automatic fire detection. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade.
22	BLEU Complex - 250 gallon propane storage tank fire	Fire destroys the propane storage tank area - spreads to UNB	Propane storage tank located [redacted] feet from UNB and [redacted] feet from fence line. Propane storage tank will be constructed and installed in accordance with NFPA 58. Propane storage tank will be located much more than the minimum [redacted] feet from the nearest building (for storage vessels up to 500 gallon) specified in NFPA 58. Site will be maintained to provide at least a 50' fire break. UNB constructed of non-combustible materials. UNB design includes fire walls and fire sprinklers in accordance with NFPA code. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade.
23	Tow vehicle fire in load-out area	A small tow vehicle will be used to tow trailers in and out of load-out area. Low consequence due to limited amount of fuel.	UNB design includes fire walls and fire sprinklers in accordance with NFPA code. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade.

Scenario #	Initiating Events	Unmitigated Consequence	Controls/Mitigating Factors
24	Natural or man-made off-site fire (brush fire, rubbish fire, careless campers, smokers, etc.)	Off-site fire that spreads to UNB.	Site will be maintained to provide at least a 50' fire break. UNB constructed of non-combustible materials. UNB design includes fire walls and fire sprinklers in accordance with NFPA code. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade.
25	Plastic tank fire caused by external events or actions such as welding, grinding, etc.	Low consequence because fire damage to more than one tank is unlikely.	UNB design includes fire walls and fire sprinklers in accordance with NFPA code. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade. No criticality issues due to concentration control. No short-term mechanism to concentrate solution.
26	HVAC duct/filter fire	Fire destroys filter with potential release to the environment. Duct fire would be small due to minimal fuel.	Duct and filter housings constructed of non-combustible material and filter material is fire retardant. Quantity of combustibles in mechanical room is small. Mechanical room protected by sprinkler system.
27	Electrical Room short circuit	Small fire in the electrical room burning up circuit breakers and distribution panels. Low combustible load, and contained in the electrical room	UNB design includes fire walls and fire sprinklers in accordance with NFPA code. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade.
28	Carelessness in the Office area	Moderate fire due to increased combustible load, potentially destroying offices. Contained in the office area due to fire wall separation from controlled area	UNB design includes fire walls and fire sprinklers in accordance with NFPA code. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade.

Scenario #	Initiating Events	Unmitigated Consequence	Controls/Mitigating Factors
29	Fire in mechanical room	Fire involving natural gas heating unit, HVAC equipment, air compressors, electrical equip. Contained in mechanical room.	Natural gas heating unit has burner management system designed in accordance with industry standards and verified by UL/FM. Gas supply system and piping installation in accordance with NFPA 58. UNB design includes fire walls and fire sprinklers in accordance with NFPA code. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade.
30	Lightning	Local destruction due to large energy release - small fire results	Site will be maintained to provide at least a 50' fire break. UNB design includes lightning protection per NFPA 780, fire wall, and fire sprinklers in accordance with NFPA code. UNB constructed of non-combustible materials. Response groups include Erwin Fire District Response (primary responder) & NFS Fire Brigade.

Appendix C

Plant Layout and Building Descriptions with

IPF Warehouse, Studsvik and Proposed BLEU Complex

Appendix D

NFS Site Area Map

Appendix E

Approximate 100 Year Flood Plain

Appendix F

Aerial View of Facility