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## ENGINEERING DATA TRANSMITTAL

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|        |       | Env.                                                                            |                      |          |          |          |               |          |          |        |       |
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# Spent Nuclear Fuel Canister Storage Building Conceptual Design Report

C.E. Swenson

Westinghouse Hanford Company, Richland, WA 99352

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Abstract: This Conceptual Design Report provides the technical basis for the Spent Nuclear Fuels Project, Canister Storage Building, and as amended by letter (correspondence number 9555700, M.E. Witherspoon to E.B. Sellers, "Technical Baseline and Updated Cost Estimate for the Canister Storage Building", dated October 24, 1995), includes the project cost baseline and Criteria to be used as the basis for starting detailed design in fiscal year 1995.

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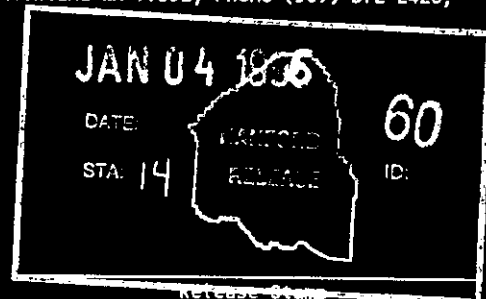
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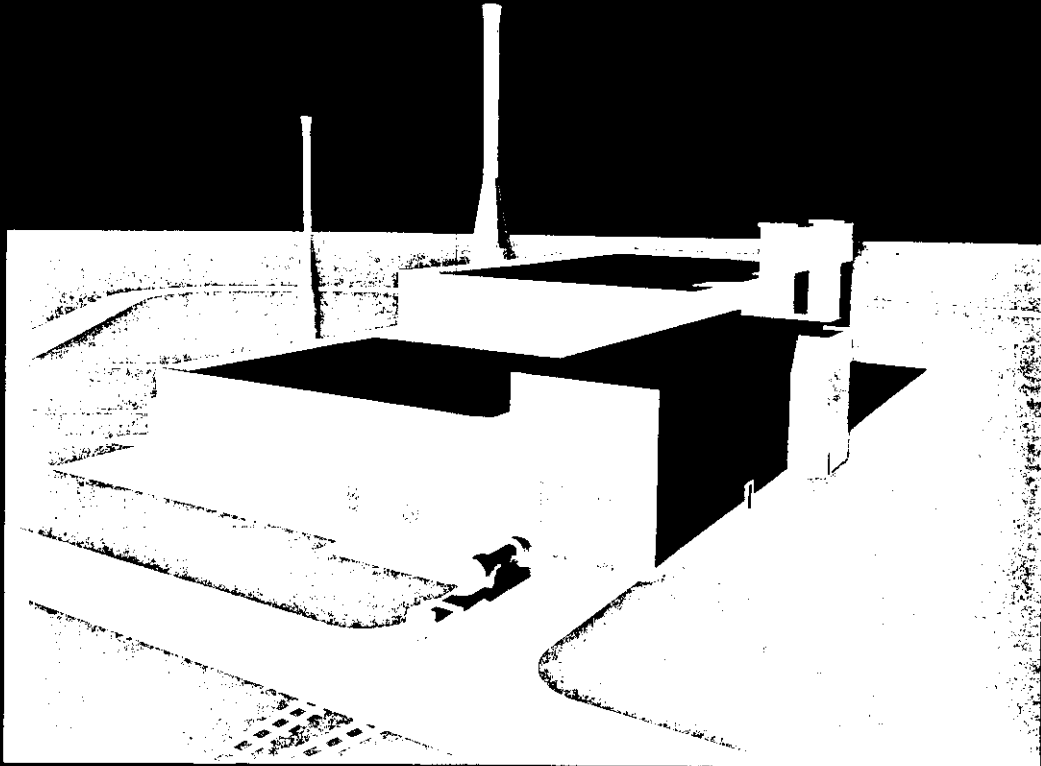
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# **SPENT NUCLEAR FUEL CANISTER STORAGE BUILDING Conceptual Design Report**

Prepared for  
**Westinghouse Hanford Company**



Prepared By  
**Fluor Daniel, Inc.**  
**Government Services Operating Company**  
**July 1995**



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## LIST OF ACRONYMS

|        |                                                 |
|--------|-------------------------------------------------|
| ACD    | Advanced Conceptual Design                      |
| A/E    | Architect/Engineer                              |
| ALARA  | As Low as Reasonably Achievable                 |
| BA/BO  | Budget Authorization/Budget Outlay              |
| B&O    | Business and Occupation Tax                     |
| CDR    | Conceptual Design Report                        |
| CEDE   | Committed Effective Dose Equivalent             |
| CFD    | Computational Fluid Dynamic                     |
| CR     | Change Request                                  |
| CSB    | Canister Storage Building                       |
| CTEDE  | Cumulative Total Effective Dose Equivalent      |
| CWBS   | Contract Work Breakdown Structure               |
| DBA    | Design Basis Accident                           |
| DBE    | Design Basis Earthquake                         |
| DBW    | Design Basis Wind                               |
| DCS    | Distributed Control System                      |
| DOE    | Department of Energy                            |
| DOE-RL | Richland Operations (U.S. Department of Energy) |
| EHW    | Extremely Hazardous Waste                       |
| EPA    | Environmental Protection Agency                 |
| ESAAB  | Energy System Acquisition Advisory Board        |
| ES&H   | Environmental, Safety and Health                |
| EU     | Electrical Utility                              |
| F&Rs   | Functions and Requirements                      |
| FDAS   | Field Data Acquisition System                   |
| FDI    | Fluor Daniel, Inc.                              |
| FHA    | Fire Hazards Analysis                           |
| GFE    | Government - Furnished Equipment                |
| GFY    | Government Fiscal Year                          |
| HVAC   | Heating, Ventilation and Air Conditioning       |
| HID    | High-Intensity Discharge                        |
| HLW    | High Level [radioactive] Waste                  |
| HP     | Health Physics                                  |
| HS     | Hanford Site                                    |
| HPS    | High Pressure Sodium                            |
| HSSA   | Hanford Site Stabilization Agreement            |
| HWVP   | Hanford Waste Vitrification Plant               |
| ICE    | Independent Cost Estimate                       |
| IES    | Illumination Engineering Society                |
| ISFSIs | Independent Spent Fuel Storage Installations    |
| K-D    | Key Decision                                    |
| LANL   | Los Alamos National Laboratory                  |
| LATA   | Los Alamos Tech Associates                      |
| LLW    | Low Level [radioactive] Waste                   |
| LPS    | Low Pressure Sodium                             |
| MAR    | Material At Risk                                |
| MCO    | Multi-Canister Overpack                         |
| MCO(K) | MCO Received from K-Basin                       |



## LIST OF ACRONYMS

|        |                                                  |
|--------|--------------------------------------------------|
| MCO(O) | Empty MCO                                        |
| MCO(S) | MCO Received from Stabilization Facility         |
| MHM    | MCO Handling Machine                             |
| MIC    | Microbiologically Influenced Corrosion           |
| MOI    | Maximum Offsite Individual                       |
| MTO    | Material Take Off                                |
| NDE    | Non-Destructive Examination                      |
| NFPA   | National Fire Protection Association             |
| NPH    | Natural Phenomena Hazards                        |
| NRC    | Nuclear Regulatory Commission                    |
| PA     | Public Address                                   |
| PC     | Performance Category                             |
| PGA    | Peak Ground Acceleration                         |
| PHA    | Preliminary Hazards Analysis                     |
| PSAR   | Preliminary Safety Analysis Report               |
| PSE    | Preliminary Safety Evaluation                    |
| PWBS   | Project Work Breakdown Structure                 |
| RAZ    | Radiation Access Zone                            |
| RCRA   | Resource Conservation and Recovery Act           |
| RF     | Release Fraction                                 |
| ROM    | Rough Order of Magnitude                         |
| RR     | Respiration Rate                                 |
| RWP    | Radiation Work Permit                            |
| SA     | Specific Activity                                |
| SAR    | Safety Analysis Report                           |
| SC     | Safety Class                                     |
| SCT    | Shielded Canister Transporter                    |
| SDC    | Hanford Plant Standards Standard Design Criteria |
| SNF    | Spent Nuclear Fuel                               |
| SNFP   | Spent Nuclear Fuel Project                       |
| SOP    | Step-Off-Pads                                    |
| SS     | Stainless Steel                                  |
| SSCs   | Structures, Systems and Components               |
| SSE    | Safe Shutdown Earthquake                         |
| SSF    | Staging and Storage Facility                     |
| SWP    | Special Work Permit                              |
| TEDF   | Treated Effluent Disposal Facility               |
| TSD    | Treatment, Storage and Disposal                  |
| TSR    | Technical Safety Requirements                    |
| TWRS   | Tank Waste Remediation System                    |
| UPS    | Uninterruptible Power Supply                     |
| WAC    | Washington Administrative Code                   |
| WBS    | Work Breakdown Structure                         |
| WHC    | Westinghouse Hanford Company                     |

## EXECUTIVE SUMMARY

This Conceptual Design was performed for the Canister Storage Building (CSB) of the Hanford Waste Vitrification Plant (HWVP) Project to serve as the Staging and Storage Facility (SSF) for the Spent Nuclear Fuel (SNF) Project and Safely Store N-Reactor spent fuel now located at K-Basins 100 KW and 100KE. The CSB will store spent N-Reactor fuel in Multi-Canister Overpacks (MCOs) until a Stabilization Facility is available to stabilize the fuel. After stabilization of the fuel, the MCOs will be returned to the CSB for interim storage until a geologic repository is available for final disposal.

This conceptual design will provide the technical basis for the project cost baseline and for starting detail design in fiscal year 1996.

The agreement resulting from an alignment meeting conducted at the onset of the Conceptual Design to ensure a common understanding of the project requirements among the SNF CSB team members defined the purpose of the project to be:

"Build a safe staging and interim storage facility for the Spent Nuclear Fuels Project."

Also, a prioritized list of key result areas deemed essential to achieve this purpose were identified:

1. Safe facility
2. Ready to receive fuel by 12/97
3. Design and build to \$80 million or less
4. Meet functional and operations requirements
5. Demonstrate streamlined and accelerated project execution
6. Public acceptance

This report used the "Staging and Storage Facility Feasibility Study" report dated February 1995 and the "Canister Storage Building Trade Study" report dated May 1995 as the basis for development of the conceptual design. The Feasibility Study confirmed the viability of adapting the current CSB as the SSF. Two concepts were investigated, 1) the use of water cooling prior to stabilization of the fuel followed by passive dry storage and 2) the use of refrigerated air cooling prior to stabilization followed by passive dry storage. The Trade Study further evaluated the impact of several technical options based on the Feasibility Study Concept 2D selected by WHC with modifications.

Concept 2D as modified for the Trade Study required the facility to store 750 MCOs with 10 fuel canisters stacked five high per MCO. The MCOs were stored in 440 CORTEN steel storage tubes in only two of the three vaults (220 per vault). The vaults containing tubes

were cooled with 35°F refrigerated air during the staging phase and convective cooling after all the fuel had been stabilized. The MCO temperatures were limited to 100°F during staging and 400° during interim storage. Heat generation per MCO was 221 W (Nominal) and 482 W (Limit), based on an 80% Nominal and 20% Limit distribution.

The results of the Trade Study indicated that Concept 2D as modified was not feasible. The high heat load per MCO and 80/20 MCO distribution would require 35°F refrigerated air operating in excess of 500,000 CFM to achieve a 105°F MCO temperature, not 100°F as required. Furthermore, accelerated hydrogen gas generation due to water in the MCOs at elevated temperature would increase the MCO venting and purging requirements. Roughly 25% of all tubes (nearly 100) would require venting daily during the staging phase prior to stabilization. Also, the 100°F MCO temperature would further exacerbate microbiological induced corrosion (MIC), reducing the fuel storage time and life of the MCO. Additional concerns were raised regarding the impacts to the facility for ensuring worker safety due to increased MCO radionuclide content.

The Trade Study included an evaluation of the technical, cost and schedule impact of eight independent Trade Studies. The results concluded that the use of carbon steel storage tubes was feasible and that the possible implications of RCRA compliance for storage tube leak detection, if applicable, would be not only difficult and expensive, but would also extend the construction schedule.

Upon review of the CSB Trade Study results, the need to determine a path forward for these technical issues was recognized. WHC gave immediate interim direction to proceed with development of the conceptual design on the basis that the storage tubes would be constructed of carbon steel and filled with water during the staging mode, in order to allow conceptual design to proceed based on maintaining 100°F in the hottest MCO. Also, in the interests of minimizing cask weight and impacts on the crane and facility while operating philosophy and health physics criteria were being assessed, WHC directed that radiation exposure criteria be set at 10 mr/hr at 3 feet from the cask and 20 mr/hr on contact.

Subsequent redirection was received from WHC as decisions were made in regards to further definition of MCO characteristics and MCO conditioning options. The conceptual design was redirected to be completed on the basis of a cold vacuum dried MCO with a maximum allowable temperature during staging of 400°F and venting being required only during staging. The capabilities for receiving shipments were reduced to two MCOs per day. Also, previously directed radiological dose levels were superseded by the limits imposed by 10 CFR Part 835.202 and shielding design should be based on an ALARA analysis.

The current CSB conceptual design reflects a facility which is based on the results of a preliminary ALARA analysis indicating an allowable cask dose of 0.2 mr/hr. As a result, certain features of the facility design were significantly upgraded to accommodate the more stringent radiological design requirements. Certain areas of the facility were modified to be concrete enclosed for shielding purposes including the addition of shield windows and doors. Cask and MCO handling equipment will need to be remotely operated, and additional airlocks were added for HVAC zone confinement. Due to thicker and hence heavier casks, crane capacities, sizes and weights increased.

Correlation between DOE and NRC seismic requirements is currently unresolved. Pending WHC determination, the current conceptual design continues to be based on a 0.35 g ground acceleration.

Also, in a effort to minimize the construction schedule, modular construction concepts were evaluated and feasible options were identified for further investigation.

The capability to provide storage of Hanford's cesium and strontium capsules at the CSB was evaluated by WHC under a study separate from the CSB Conceptual Design and is not reflected in this report.

A comparative summary of the cost estimates for each Concept 2D base case (i.e., Feasibility Study, Trade Study and Conceptual Design) is reflected in Table 1. The Conceptual Design cost estimate reflects structural, mechanical, HVAC and electrical features to support the radiological design requirements. In addition, the cost for a Sample Building to test Drain Line (DRX) water transported to the Treated Effluent Disposal Facility (TEDF) was added. Costs associated with the transport and facility casks and the railroad donkey engine were excluded since they are being considered separately as Operations funded. Cost estimate detail is presented in Section 3.0.

In order to accelerate the fast track schedule, an at-risk approach for developing the Conceptual Design Report concurrently, with the Performance Specification requirements was utilized. This necessitated using an interactive process to apply "design to cost" principles for meeting the total project cost of \$80 million. Employed successfully, this process identifies cost drivers and engineering options along with associated cost trade-offs. In this case, radiological design features to satisfy ALARA (as low as reasonably achievable) requirements were identified as the major cost driver and alternate approaches were evaluated.

These "design to cost" considerations and reduced cost estimate figures are reflected in Section 3.5. Note that cesium and strontium capsule storage capabilities would result in many of the cost reductions being added back into the total facility cost. A

revision to the draft Performance Specification will be made prior to final issue for Detailed Design to reflect "design to cost" requirements for design compliance.

TABLE 1  
 SNF CSB CONCEPTUAL DESIGN  
 COST IMPACT  
 (\$ 1995)

| (\$ x 1,000)                            | Concept 2D<br>100' Refig<br>Air<br>3 Vaults<br>1 Empty<br>440 CORTEN<br>Stg Tubes | Concept 2D<br>Revised <sup>(1)</sup><br>100' Refig<br>Air<br>3 Vaults<br>1 Empty<br>440 CORTEN<br>Stg Tubes | Conceptual<br>Design CSB <sup>(2)</sup><br>400' Nat<br>Circ<br>3 Vaults<br>1 Empty<br>440 C.S.<br>Stg Tubes |
|-----------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| Load In / Load Out                      | 6,604                                                                             | 6,474                                                                                                       | 9,938                                                                                                       |
| Infrastructure                          | 1,417                                                                             | 1,417                                                                                                       | 2,208                                                                                                       |
| <u>Vault</u>                            | <u>41,246</u>                                                                     | <u>37,985</u>                                                                                               | <u>43,803</u>                                                                                               |
| Total Direct Const \$ (1995)            | 49,267                                                                            | 45,876                                                                                                      | 55,949                                                                                                      |
| Title II Design                         | 8,200                                                                             | 6,900                                                                                                       | 9,000                                                                                                       |
| Title III Engineering and<br>Inspection | 4,400                                                                             | 3,700                                                                                                       | 4,480                                                                                                       |
| Construction Management                 | 4,000                                                                             | 3,700                                                                                                       | 4,040                                                                                                       |
| <u>Project Management</u>               | <u>4,000</u>                                                                      | <u>3,700</u>                                                                                                | <u>3,800</u>                                                                                                |
| Total, 1995 \$                          | 69,867                                                                            | 63,876                                                                                                      | 77,269                                                                                                      |
| Escalation                              | 4,145                                                                             | 3,796                                                                                                       | 3,291                                                                                                       |
| <u>Contingency</u>                      | <u>12,388</u>                                                                     | <u>11,344</u>                                                                                               | <u>14,529</u>                                                                                               |
| Total Estimated Cost (TEC)              | 86,400                                                                            | 79,016                                                                                                      | 95,089                                                                                                      |

(1) Revised Concept 2D reflects the deletion of the SSF Cask Loader, Storage Gate/Plug Flask Unit and the Donkey Engine from the capital cost estimate. The estimate further reflects mechanical changes to accommodate heavier casks.

(2) The MCO Handling Machine (Cask portion) and MCO impact absorbers have been excluded from the vault capital cost estimate.



## 1.0 INTRODUCTION

### 1.1 BACKGROUND

#### 1.1.1 Spent Nuclear Fuel Project Recommended Path Forward

In October 1994, Westinghouse Hanford Company (WHC) published a report (WHC-EP-0830) entitled Hanford Spent Nuclear Fuel Project Recommended Path Forward. That report described a recommended approach for expedited removal of spent nuclear fuel, including sludge, from the K Basins at Hanford and its placement in a stable dry storage configuration until final disposition is possible. An essential part of the recommended approach was the use of a new facility, called the Staging and Storage Facility (SSF), to perform two principal functions. The first was to provide safe storage for the wet fuel and sludge from the K Basins until it can be dried and passivated in another new facility, the Stabilization Facility. The second principal function of the SSF was to provide passive dry storage of the stabilized fuel and sludge until final disposition.

Although the location of these new facilities was not selected, movement of the spent nuclear fuel and sludge away from the Columbia River was an important objective. One of the leading options being considered was the construction of the required facilities within the 200 Area of the Hanford Reservation. This approach was most compatible with current plans to centralize future Hanford Reservation waste operations in the 200 Areas.

Another related project, which had previously been initiated to vitrify Hanford defense liquid high-level wastes into borosilicate glass, was the Hanford Waste Vitrification Plant (HWVP) Project. This project, which was to be located in the 200 East Area, included a Canister Storage Building (CSB) to provide passive dry storage of stainless steel canisters containing the borosilicate glass until they could be sent to a geologic repository. Design of the CSB was complete and construction was underway when the HWVP Project was put on hold in 1993.

Since the functions of the SSF and CSB are very similar, since the CSB is located in an area that is a prime candidate for the SSF, and since there are no other current plans to resume construction of the HWVP or otherwise utilize the partially completed CSB, it was logical to consider whether the CSB design and construction could be adapted to meet the needs of the SSF. If this were possible, it could result in significant cost and schedule benefits to the WHC Spent Nuclear Fuel Project. A study was therefore initiated to investigate the technical feasibility of the adaptation and quantify the resultant cost and schedule benefits.



### 1.1.2 SSF Feasibility Study

In January 1995 Westinghouse Hanford Company (WHC) commissioned Fluor Daniel to investigate the feasibility of adapting the design of the HWVP Canister Storage Building (CSB) to meet the needs of the WHC Spent Nuclear Fuel Project for a Staging and Storage Facility (SSF) and to develop Rough Order of Magnitude (ROM) cost and schedule estimates. The SSF is to store spent N-Reactor fuel in Multi-Canister Overpacks (MCOs) filled with water until a Stabilization Facility is available to stabilize the fuel. After stabilization of the fuel the MCOs will be returned to the SSF for storage until a geologic repository is available for final disposal. The study investigated two concepts for the SSF which were selected by WHC, 1) the use of water cooling prior to stabilization of the fuel followed by passive dry storage, and 2) the use of refrigerated air cooling prior to stabilization followed by passive dry storage.

The design criteria for the study stipulated that the water temperature in the MCO prior to stabilization is to be limited to 50° F maximum and the fuel centerline temperature after stabilization is to be limited to 400° F maximum.

The study report was completed in late February 1995 and was issued to WHC. The study found that it is feasible to adapt the design and partially completed construction of the CSB to meet the functions and requirements of the SSF using either of the specified concepts.

Under Concept 1, the MCOs are stored in racks in a single layer in an open pool of water with a recirculating water treatment system which returns the water to the pool at 44-45° F. This portion of the SSF utilizes approximately 1/3 of the completed CSB foundation. The balance of the facility, which utilizes the remaining 2/3 of the CSB foundation and the design of the CSB dry storage vaults, is constructed so that it is operational at the same time as the Stabilization Facility. After stabilization, the MCOs are returned to the newly constructed dry storage vaults of the SSF, where they remain in passive dry storage until a geologic repository is available for final disposal.

Two alternatives were evaluated under Concept 1. Alternative 1B provides 512 storage tube locations for dry storage in two vaults and does not require any addition to the CSB foundation footprint. Alternative 1C provides 660 storage tubes and requires the addition of space for another vault to the CSB footprint.

Under Concept 2, the MCOs are stored in two layers in water filled tubes extending into three, below grade, concrete enclosed, shielding vaults cooled by recirculating 35° F refrigerated air. This utilizes the entire foundation and design of the CSB. After stabilization, the storage tubes are drained of water and the MCOs

reinstalled. When all the MCOs have been stabilized, the recirculating refrigerated air system is shut down and natural circulation passive air cooling established.

The study also included an evaluation of the use of a Shielded Canister Transporter vs. an overhead cask/crane system to install and remove the MCOs from the storage tubes. This evaluation resulted in the conclusion that the overhead cask/crane system is preferred. Concepts 1 and 2 were therefore both evaluated on the basis of an overhead cask/crane system.

During review of the draft of this report, interest was expressed in other alternatives which were not constrained by the Design Basis. In particular, it was indicated that it was possible that the 50°F MCO temperature limit prior to stabilization could be relaxed. If this temperature were relaxed to about 100°F, it would be possible to store the MCOs in dry CORTEN storage tubes cooled by refrigerated air. Relaxing the MCO temperature limit prior to stabilization would not have any significant affect on the design or cost of the water cooled alternatives, i.e. Concept 1.

In order to permit evaluation of these other alternatives against those previously studied, ROM cost estimates were developed for the following additional alternatives:

Alternative 2C. This alternative is the same as Alternative 2A (660 storage tubes) except that the storage tubes are not filled with water, allowing CORTEN to be used, which results in an MCO temperature of about 100°F when cooled with 35°F refrigerated air.

Alternative 2D. This Alternative is the same as Alternative 2C except that storage tubes are installed in only two of the three vaults, resulting in a total of 440 storage tubes. The number of storage tubes in two vaults could be increased to 512 using the same configuration as for Alternative 1B, but the cost of this was not evaluated. The MCO temperature would be about the same as for Alternative 2C (about 100°F).

Alternative 2E. This alternative is the same as Alternative 2A except that storage tubes are installed in only two of the three vaults, resulting in a total of 440 storage tubes. As above, the number of storage tubes in two vaults could be increased to 512. The MCO temperature would be about the same as for Alternative 2A (about 50°F).

Alternative 3A. This alternative is the same as Alternative 2C (660 storage tubes) except that cooling is by natural circulation of ambient air. This results in a fuel temperature of about 185°F if the MCO is filled with water or about 230°F if the MCO is not filled with water (damp) when the ambient air temperature is 115°F.

Alternative 3B. This alternative is the same as Alternative 3A except that storage tubes are installed in only two of the three vaults, resulting in a total of 440 storage tubes. As above, the number of storage tubes in two vaults could be increased to 512. The MCO temperature would be about the same as for Alternative 3A (about 185-230°F).

A comparison of the capital costs of the above alternatives against those previously presented showed that relaxing the MCO temperature prior to stabilization to about 100°F, can enable the capital cost of the refrigerated air cooled alternatives to fall below that of the comparable water cooled alternatives. Further relaxation of the MCO temperature prior to stabilization to 185-230°F, could allow the use of natural circulation cooling resulting in additional reductions in the capital cost of the facility.

### 1.1.3 CSB Trade Study

This study was performed in May 1995 to further evaluate the impact of several technical issues related to the usage of the Canister Storage Building (CSB) to safely stage and store N-Reactor spent fuel. Each technical issue formed the basis for an individual Trade Study that was used to develop Rough Order of Magnitude (ROM) cost and schedule estimates. The study used Concept 2D from the SSF Feasibility Study as the basis for development of the individual trade studies.

Concept 2D was a variation of Concepts 2A and 2C presented in the feasibility study. Concept 2D had storage tubes installed in only two of the three vaults, resulting in a total of 440 storage tubes. The storage tubes were fabricated of weathering steel (e.g., CORTEN) material. The vaults containing tubes were cooled with 35°F refrigerated air during the staging phase and convective cooling once all the fuel had been stabilized. The MCO characteristics included 880 MCOs with 8 fuel canisters stacked four high per MCO and a temperature of 100°F. Heat generation per MCO was 176 W(Nominal) and 328 W(Limit), based on an 80% Nominal, 5% Limit and 15% below Nominal distribution. The fuel centerline temperature after stabilization was limited to 400°F.

To perform the trade studies, WHC requested further modification to Concept 2D, including revising MCO characteristics. Concept 2D was to be adjusted to accommodate 750 MCOs with 10 fuel canisters stacked five high per MCO with a maximum temperature of 100°F. Heat generation per MCO was increased to 221 W(Nominal) and 482 W(Limit), based on an 80% Nominal and 20% Limit distribution. It was further instructed not to reconfigure the building for 750 MCOs, but to continue on a with 220 storage tube per vault arrangement. To ensure that worst case loads were used for heat load calculations, it was assumed that all 220 tubes per vault were

filled with two MCOs each. The fuel centerline temperature remained at 400°F after stabilization.

The results of the re-evaluation of Concept 2D with the modifications indicated found that it was not feasible to adapt the CSB to comply with the functions and requirements of the SSF as defined. The high heat load per MCO and 80/20 MCO distribution would require 35°F refrigerated air operating in excess of 500,000 CFM to achieve a 105°F MCO temperature, not 100°F as required.

The re-evaluation also highlighted several other technical challenges that would need to be overcome to meet operating and safety concerns. By increasing the allowable MCO temperature requirement to 100°F, hydrogen gas production due to water in the MCOs will be increased requiring the tubes to be vented and purged more often. The volume of hydrogen gas would be high enough to warrant the purging of nearly 100 tubes per day or roughly 25% of all tubes would require purging daily during the staging phase prior to stabilization. The 100°F MCO temperature would further exacerbate Microbiological Influenced Corrosion (MIC) reducing the fuel storage time and life of the MCO. The radionuclide concentrations are also much higher for the revised MCO requiring significantly thicker shielding, especially for the facility (handling) cask within the CSB, to ensure worker safety. The heavier cask will also increase the crane capacities required to handle the material flow. The dose rates and exposure concerns would further complicate use of the empty vault in the future. To protect personnel in the future it may be required to isolate the empty vault with sufficient shielding at the air intake and exhaust plenum, as well as increase the common wall thickness..

The study also included an evaluation of the technical, cost and schedule impacts to Concept 2D due to eight independent Trade Studies as follows:

- Trade Study A evaluated the impact of Safety Class 1 HVAC confinement for the Operating Area. A redundant ventilation system would be required with Class 1E emergency generators. The cost impact was estimated at \$2.5 million.
- Trade Study B investigated deletion of the MCO Servicing Area. Features of this option reflect an MCO shipped dry in a bottom/top loading cask with a transfer cart between unloading and operating areas. The cost reduction was estimated to be \$3.2 million.
- Trade Study C investigated deletion of the Cask Wash Area. Elimination of this function minimizes waste water handling and simplifies cask receipt. The cost reduction of \$1.2 million was estimated.

- Trade Study D evaluated elimination of the second railroad track service. This reduced the size of the cask receipt area and resulted in a reduced cask handling capacity. The cost impact was estimated as a reduction of approximately \$147,000.
- Trade Study E investigated alternate storage tube material. Assuming the use of carbon steel, which appeared feasible based on preliminary assumptions, a cost savings of \$3.4 million was indicated.
- Trade Study F considered the implications of reducing daily MCO shipments from 4 to 2. This would result in reduced handling requirements amounting to a \$274,000 savings.
- Trade Study G to evaluate damp-dried MCOs was not considered feasible as a result of the inability to maintain a 100°F temperature limit for wet MCOs. 500,000 CFM of 35°F supply air would only lower the MCO temperature to 167°F.
- Trade Study H considered the impact of RCRA applicability. If leak detection were required for the tubes, it would be complex and costly. The construction schedule would be extended by 2 months minimum and costs would be expected to increase by \$4.5 million.

The estimate for Concept 2D was updated to reflect structural and mechanical changes. An allowance was left in the estimate for HVAC equipment with the understanding that a change may occur as a result of the technical feasibility evaluation. In addition, the cost of transport and facility casks and the railroad donkey engine were excluded from the Concept 2D estimate update to more accurately reflect only facility cost.

#### 1.1.4 Conceptual Design

The Spent Nuclear Fuel CSB Conceptual Design effort was started in May 1995 and was performed concurrently with the CSB Trade Study in order to support an accelerated schedule for issuing the Conceptual Design Report and Cost Estimate by July 24, 1995. Upon review of the CSB Trade Study results, the need to determine a path forward for these technical issues was recognized. WHC gave immediate interim direction to proceed with development of the conceptual design on the basis that the storage tubes would be constructed of carbon steel and filled with water during the staging mode. The intent of this change was to allow conceptual design to proceed based on maintaining 100°F in the hottest MCO. Also, in the interests of minimizing cask weight and impacts on the crane and facility while operating philosophy and health physics criteria were being assessed, WHC directed that radiation exposure criteria be set at 10 mr/hr at 3 feet from the cask and 20 mr/hr on contact.

Subsequent redirection was received from WHC as decisions were made in regards to further definition of MCO characteristics and MCO conditioning options. The conceptual design was redirected to be completed on the basis of a cold vacuum dried MCO with a maximum allowable temperature during staging of 400°F and venting being required only during staging. The capabilities for receiving shipments were reduced to two MCOs per day. Also, previously directed radiological dose levels were superseded by the limits imposed by 10 CFR Part 835.202 and with shielding design to be based on an ALARA analysis.

The current CSB conceptual design reflects a facility which is based on the results of a preliminary ALARA analysis indicating an allowable cask contact dose of 0.2 mr/hr. As a result, certain features of the facility design were significantly upgraded to accommodate the more stringent radiological design requirements. Certain areas of the facility were modified to be concrete enclosed for shielding purposes. Cask and MCO handling equipment will need to be remotely operated, and additional airlocks were added for HVAC zone confinement. Due to thicker and hence heavier casks, crane capacities, sizes and weights increased.

Application of "design to cost" considerations identified these ALARA design features to be major cost drivers. Alternate engineering options and associated cost reductions are summarized in Section 3.5.

The concepts and cost estimates developed in the SSF Feasibility Study and in the CSB Trade Study did not reflect a facility which was intended to decontaminate casks and MCOs. The current CSB conceptual design only provides areas for limited small equipment item decontamination.

Correlation between DOE and NRC seismic requirements is currently unresolved. Pending WHC determination, the current conceptual design continues to be based on a 0.35 g ground acceleration.

Also, in a effort to minimize the construction schedule, modular construction concepts were evaluated and feasible options were identified for further investigation.

## **1.2 OBJECTIVES**

### **1.2.1 SNF SSF CSB Project Alignment**

On April 27, 1995, an alignment meeting was held in Richland, Washington with key members of the SNF CSB team. The purpose of the meeting was to align DOE, WHC, ICF Kaiser and Fluor Daniel to ensure a common understanding of the CSB project requirements, roles and responsibilities, priorities and expectations. A purpose

statement was developed and key result areas necessary to achieve the agreed-upon purpose were identified.

The purpose of the SNF CSB project was defined to be:

"Build a safe staging and interim storage facility for the Spent Nuclear Fuels Project."

In order to achieve this purpose, the following prioritized list of key result areas were identified as essential.

1. Safe facility
2. Ready to receive fuel by 12/97
3. Design and build to \$80 million or less
4. Meet functional and operational requirements
5. Demonstrate streamlined and accelerated project execution
6. Public acceptance

#### **1.2.2 Conceptual Design Report**

The objective of this report is to provide the technical basis for validating a project cost baseline in July 1995 and for starting detailed design in fiscal 1996. The cost estimate will be developed for an Independent Cost Estimate (ICE) Review.

#### **1.3 SCOPE OF WORK**

The scope of work was to perform a conceptual design of the Canister Storage Building using Concept 2D of the Fluor Daniel Staging and Storage Facility Feasibility Study dated February 1995, and as developed in the Canister Storage Building Trade Study by Fluor Daniel dated May 1995, and as modified by subsequent WHC letters of direction 9553074/370252-020 dated June 5, 1995 and 9553364/370252-022 dated June 20, 1995. The work scope was defined in accordance with Statement of Work, Revision 2, dated May 17, 1995 in Attachment 1 of WHC Work Order TVW-SVV-370252, Modification No. 91.

#### **1.4 DESIGN BASIS**

##### **1.4.1 HWVP FDC and TDP vs. SNF CSB Performance Specification**

One of the advantages to utilizing the CSB for the Spent Nuclear Fuel Project storage was the fact that Design Basis documentation already existed and would merely need an update to reflect the new program mission. Two documents in particular served as the primary design basis on HWVP, the Functional Design Criteria (FDC) and the Technical Data Package (TDP). For the SNF CSB, these two documents will be combined and replaced by the Performance Specification. Currently, the Performance Specification is being developed concurrently with the Conceptual Design. A draft version of the

document is currently being internally reviewed by WHC and is expected to be issued in the Advanced Conceptual Design phase as the basis for Detailed Design. To date, the Performance Specification draft, dated May 17, 1995, has served as guidance for reference only. However, the characteristics for the MCO described in Table 1-1, proposed by R. C. Cowan have been used as the basis for Conceptual Design. Due to the at-risk approach for developing the Performance Specification concurrently with the Conceptual Design Report in order to accelerate schedule, it was recognized that both would evolve interactively with iterative changes. In response to "design to cost" considerations identified herein regarding ALARA compliance, the draft Performance Specification will be revised accordingly prior to final issue for Detailed Design.

#### 1.4.2 Conceptual Design Statement of Work

The criteria for the conceptual design were based on that of the CSB Trade Study and as delineated in the Statement of Work, Revision 2, referenced above as follows:

The facility configuration will be based on Concept 2D (dry stage/dry store/100°F MCO/3 vaults one without tubes/weathering steel (e.g., CORTEN) tubes) and adjust capacity for 750 MCOs and 10 canisters stacked 5-high per MCO. In addition, use the criteria from the Feasibility Study with the following changes:

1. Assume 10 canisters per MCO rather than 8.
2. Temporary refrigerated air systems and equipment for staging mode, natural circulation for storage mode.
3. Delete Office Building, restrooms and other permanent facilities.

The following facility features are retained:

1. Double containment provided by MCO's and Storage Tubes.
2. CORTEN Tubes.
3. One vault unfinished but expandable to accommodate additional Hanford Fuels.
4. Footprint to accommodate adjacent stabilization facility. (Approximately 100' x 100').
5. Operating Floor to be served by forced air HVAC system; confinement not required during normal operation.
6. Staging mode - Temporary MCO venting, gas control and gas/liquid sampling capability.
7. New MCO receipt, staging and initial cask loading functions and area.
8. Cask Wash Down function and area.
9. Compliance with NRC regulations (NRC Licensable).
10. QA requirements per 10 CFR 830.120.



Table 1-1

MCO Proposed Description  
Draft Rev. A R.G. Cowan May 17, 1995  
MCO Radio Nuclide Inventory

| Radio nuclide              | Unit | Average | Maximum |
|----------------------------|------|---------|---------|
| U                          | kg   | 2,800   | 3,287   |
| Zr                         | kg   | 197     | 230     |
| Pu                         | kg   | 5       | 100     |
| Sn                         | kg   | 3       | 3       |
| Al                         | kg   | 2       | 3       |
| C                          | kg   | 2       | 2       |
| All Other                  | kg   | 4       | 5       |
| Total Mass For One MCO     | kg   | 3,013   | 3,630   |
| Co-60                      | Ci   | 197     | 786     |
| Kr-85                      | Ci   | 937     | 2,440   |
| Sr-90                      | Ci   | 14,000  | 27,941  |
| Y-90                       | Ci   | 14,000  | 27,941  |
| Cs-137                     | Ci   | 18,000  | 37,929  |
| Ba-137m                    | Ci   | 17,067  | 35,906  |
| Pm-147                     | Ci   | 1,440   | 8,180   |
| Sm-151                     | Ci   | 229     | 344     |
| Eu-154                     | Ci   | 171     | 804     |
| Pu-238                     | Ci   | 167     | 496     |
| Pu-239                     | Ci   | 300     | 499     |
| Pu-240                     | Ci   | 173     | 378     |
| Pu-241                     | Ci   | 7,840   | 35,021  |
| Am-241                     | Ci   | 420     | 742     |
| All Other                  | Ci   | 379     | 3,283   |
| Total Activity For One MCO | Ci   | 77,320  | 182,692 |

MCO General Attributes

| Parameter                               | Unit  | Average | Maximum |
|-----------------------------------------|-------|---------|---------|
| Heat <sup>(1)</sup>                     | Watt  | 221     | 482     |
| Water Weight                            | kg    | 963     | 984     |
| Stainless/Al                            | kg    | 1,274   | 1,314   |
| Total MCO Weight                        | kg    | 5,251   | 5,927   |
| Fuel Volume                             | L     | 202     | 243     |
| MCO Volume                              | L     | 1,203   | 1,265   |
| MCO Fuel Fraction                       | %     | 17      | 19      |
| MCO Length                              | cm    | 460     | 460     |
| MCO Diameter                            | cm    | 61.00   | 62.50   |
| MCO Wall Thickness                      | cm    | 1.00    | 1.00    |
| MCO Top Shield                          | cm    | 20      | 20      |
| Canisters/MCO                           |       | 10      | 10      |
| Cask (20 cm iron) Weight <sup>(2)</sup> | kg    | 20,375  | 20,763  |
| Loaded Cask & MCO                       | kg    | 25,626  | 26,690  |
| Cask & MCO                              | tons  | 28.25   | 29.42   |
| Fuel Surface                            | sq. m | 37.77   | 44.34   |
| MCO & Canisters                         | sq. m | 29.17   | 29.40   |
| Total Inside Surface                    | sq. m | 66.94   | 73.74   |

Notes: See Page 1-11

MCO Heat Capacity

| Parameter         | Unit     | Average  | Maximum   |
|-------------------|----------|----------|-----------|
| Uranium           | kw-hr/'C | 0.10     | 0.11      |
| Zirconium         | kw-hr/'C | 0.02     | 0.03      |
| Stainless steel   | kw-hr/'C | 0.11     | 0.18      |
| Water             | kw-hr/'C | 1.11     | 1.14      |
| Cask              | kw-hr/'C | 2.53     | 2.58      |
| Total             | kw-hr/'C | 3.95     | 4.05      |
| @ 10 °C           |          |          |           |
| Uranium Corrosion | g/d      | 1.74     | 20.44     |
| Gas Generation    | L/d      | 0.33     | 3.85      |
| Reaction Heat     | Watt     | 0.05     | 0.55      |
| Heat Loss         | Watt     | 36.86    | 36.86     |
| Temperature Rise  | 'C/hr    | 0.05     | 0.11      |
| @ 25 °C           |          |          |           |
| Uranium Corrosion | g/d      | 6.12     | 71.80     |
| Gas generation    | L/d      | 1.15     | 13.52     |
| Reaction Heat     | Watt     | 0.17     | 1.95      |
| Heat Loss         | Watt     | 136.31   | 136.31    |
| Temperature Rise  | 'C/hr    | 0.02     | 0.09      |
| @ 50 °C           |          |          |           |
| Uranium Corrosion | g/d      | 49.63    | 582.60    |
| Gas generation    | L/d      | 9.34     | 109.67    |
| Reaction Heat     | Watt     | 1.35     | 15.80     |
| Heat Loss         | Watt     | 302.06   | 302.06    |
| Temperature Rise  | 'C/hr    | -0.02    | 0.05      |
| @ 75 °C           |          |          |           |
| Uranium Corrosion | g/d      | 402.68   | 4,727.41  |
| Gas generation    | L/d      | 79.8     | 889.87    |
| Reaction Heat     | Watt     | 10.92    | 128.20    |
| Heat Loss         | Watt     | 467.81   | 467.81    |
| Temperature Rise  | 'C/hr    | -0.06    | 0.04      |
| @ 85 °C           |          |          |           |
| Uranium Corrosion | g/d      | 930.37   | 10,922.54 |
| Gas generation    | L/d      | 175.13   | 2,056.01  |
| Reaction Heat     | Watt     | 25.23    | 296.20    |
| Heat Loss         | Watt     | 534.11   | 534.11    |
| Temperature Rise  | 'C/hr    | -0.07    | 0.06      |
| @ 95 °C           |          |          |           |
| Uranium Corrosion | g/d      | 2,149.59 | 25,236.18 |
| Gas generation    | L/d      | 404.63   | 4,750.34  |
| Reaction Heat     | Watt     | 58.29    | 684.35    |
| Heat Loss         | Watt     | 600.41   | 600.41    |
| Temperature Rise  | 'C/hr    | -0.08    | 0.14      |

- (1) Heat generation design feed basis is calculated at 80% of the attributes shown under "Average" and 20% of those shown under "Maximum"
- (2) Cask weight not consistent with requirements to meet shielding.

The following documents were provided as supplementary technical information.

- Preliminary Safety Evaluation (PSE)
- Staging and Storage Facility - Spent Nuclear Fuels - Greenfield Study Final Report - performed by ICF-Kaiser Engineers dated March 10, 1995 (includes section delineating regulatory requirements).
- Updated MCO Description Sheet
- Level 0 Schedule
- Work Breakdown Structure (WBS)
- Staging and Storage Facility Functions and Requirements, March 31, 1995.

#### 1.4.3 WHC Direction June 5, 1995

In response to the CSB Trade Study Report result, WHC letter 9553074/370252-020, dated June 5, 1995 provided the following direction:

- Proceed with conceptual design on the basis that the storage tubes will be constructed of carbon steel and filled with water during the staging mode. The intent of this change is to allow HVAC calculations and sizing to proceed based on maintaining 100°F in the hottest MCO.
- Venting considerations should consider the temperature distribution within the MCOs with wet storage tubes. Gas venting calculations and service requirements should be based on an average temperature.
- For the purposes of conceptual design, the cask within the vault portion of the CSB should be designed for 20 mr/hr on contact or not to exceed 10 mr/hr at 3 feet with the maximum MCO. The intent of this change is to reduce cask weight and impacts on the crane and building while building operating philosophy and health physics criteria are being assessed.

#### 1.4.4 WHC Direction June 20, 1995

Further direction regarding the basis for design was received from WHC letter 9553364/370252-002, dated June 20, 1995 as follows:

- Complete the conceptual design on the basis of a dry MCO. The free water will be removed by a temperature assisted "cold" vacuum drying method. The gas release and chemical heat generation will be substantially reduced, however some venting of the MCO's will still be necessary due to H<sub>2</sub> generation by hydrolysis. This is considered to be the

staging condition. The maximum centerline temperature allowable is 400°F.

- This staging mode will require the MCOs to be eventually transported to another facility for a hot vacuum dry and then returned. Upon their return from this conditioning facility they will be sealed and will no longer require venting.
- The number of shipments will be reduced to 2 MCOs per day.
- Radiological control - This supplements previous direction to evaluate a handling cask with a contact dose rate of 20/mr per hour in an attempt to reduce crane capacity, building costs and cask costs. The actual building occupational exposures must not exceed legal limits in 10 CFR Part 835.202. Shielding design should be based on an ALARA study examining dose, costs and schedule of the proposed activities.

## 2.0 FACILITY DESCRIPTION & EVALUATION

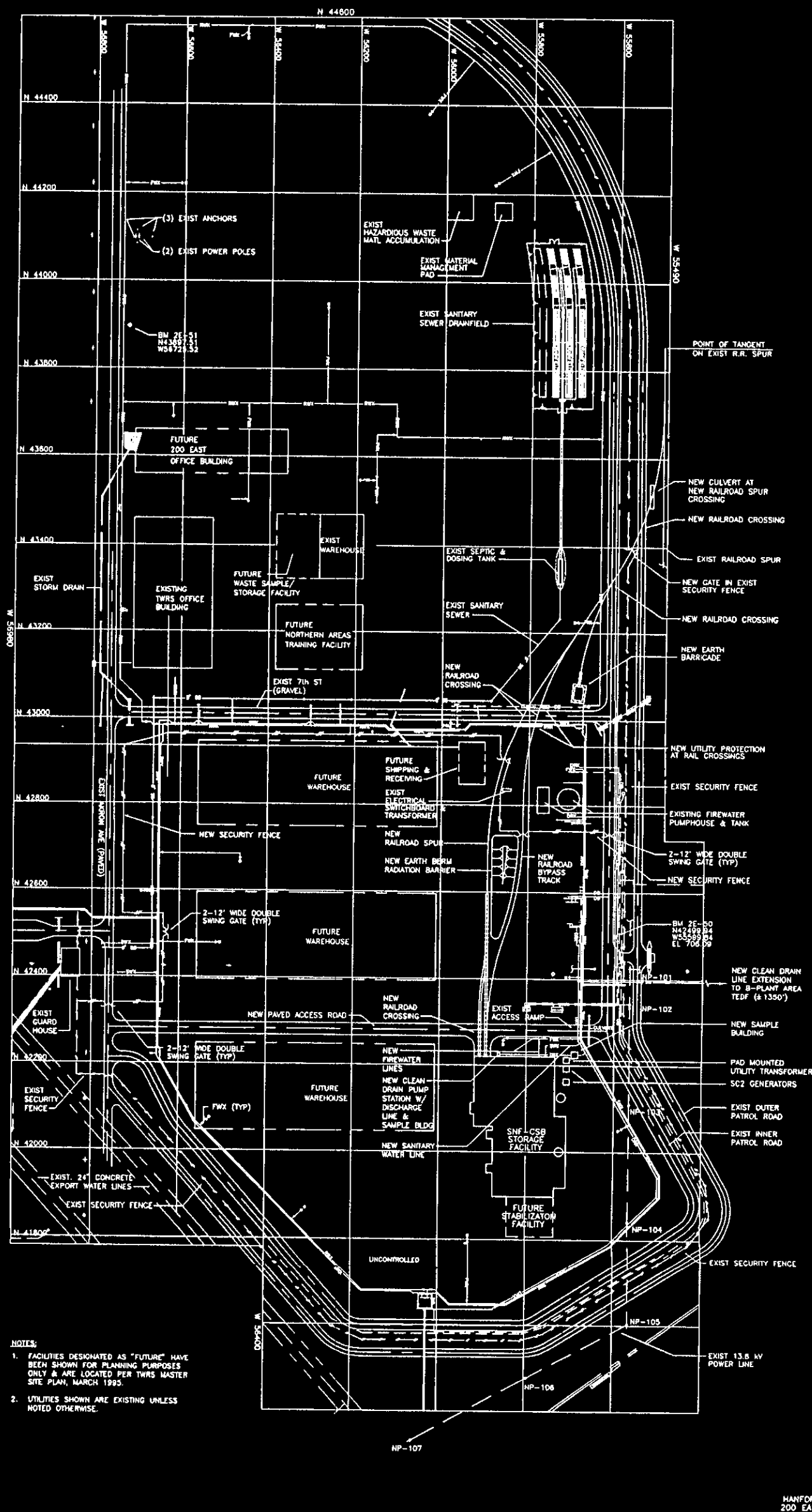
The SNF CSB configuration consists of three equally sized below-grade concrete vaults covered by a concrete operating deck. These vaults have air plenums on opposite sides. Two of the vaults are each equipped with 220 carbon steel storage tubes installed in the vertical position; the third vault will remain empty for future use. Each storage tube can accommodate two MCOs stacked two-high, and is closed and sealed by means of a shielded plug installed at the operating deck level. The operating deck and other operations areas are enclosed in a steel building. Support functions (e.g., maintenance, control room, health physics) and equipment (e.g., MCO HVAC and electrical power equipment and controls) are housed in rooms adjacent to the operations structure. MCO/Cask Receipt and Servicing (e.g. Wash Down, Load-In/Load-Out and MCO lag storage) is performed in a concrete structure adjacent to the operations and support facilities.

### 2.1 SITE PLANS

The SNF CSB is located in the 200 East Area of the Hanford Site. The approximate coordinates for this site are N 42 000, W 55 800, as originally determined by the HWVP Project. The site integration criteria followed by the HWVP Project was adopted by the SNF CSB Project in their assessment of the feasibility of adapting the HWVP CSB site and design to accomplish the mission of the SNF SSF. Utilization of the existing design and construction of the HWVP Canister Storage Building has been maximized as much as possible. Figure 2-1 shows the outline of the SNF CSB concept and an adjacent stabilization facility superimposed on a modified TWRS Master Site Plan for the former HWVP site.

Overall site grading was accomplished as part of the HWVP effort. Infrastructure in the form of unpaved patrol and site roads, fire (raw) water and sanitary (domestic) water mains, and sanitary sewer collection and treatment facilities were installed to serve the site.

The surrounding exterior area will have 2-lane service roads with an HS-20 load capacity that will serve vehicle traffic to the Load-In/Load-Out area, the HVAC area, the New MCO Receipt and Lag Storage area, and the Emergency Generator area. The balance of the exterior area will have gravel surface stabilization. Rail access will be provided from the existing rail lines to the north and east of the site. Note that two rail/truck entries are provided into the SNF CSB. The purpose of the second track/truck access is to provide operational redundancy and not to increase shipping capacity, which was investigated in the SNF CSB Trade Study Final Report (May 1995). Road and rail access are described below.



- NOTES:
1. FACILITIES DESIGNATED AS "FUTURE" HAVE BEEN SHOWN FOR PLANNING PURPOSES ONLY & ARE LOCATED PER TWRS MASTER SITE PLAN, MARCH 1995.
  2. UTILITIES SHOWN ARE EXISTING UNLESS NOTED OTHERWISE.



SNF CSB  
CONCEPTUAL DESIGN  
MASTER SITE PLAN  
FIGURE 2-1

CADSWAN

7-7-95

### 2.1.1 Rail Line Access

Rail service is available to the overall HWVP site along the north and east boundaries by means of existing rail lines. At the north boundary is the main line leading into the 200 East area. At the east boundary is the spur line that is used to convey coal to the steam plant located southeast of the SNF CSB site. The preferable alternate for the present project is to bring a spur from the rail line along the east boundary. To come from the north along the alignment originally designed for HWVP would bisect the remainder of the HWVP site. Since the future uses of the HWVP site have not been determined, it is felt better not to encumber the site unnecessarily.

A bypass track will be provided as part of the new rail construction to allow the locomotive to change ends on inbound transport trains in order to transition from "pull" to "push" mode to deliver the rail car with cask to the SNF CSB receiving area. An earthen berm or other radiation barrier will be provided between the main spur and the bypass track to shield the locomotive crew from radiation during the transition bypass operation. Two entry tracks will be provided at the SNF CSB, per WHC direction, to provide a backup point of entry for shipments in case a rail car or truck becomes inoperable while inside the SNF CSB receiving area. Both tracks will be flush with the receiving area floor to accommodate either truck or rail operation in both bays. Note that the purpose of the second track is to provide operational redundancy and not to increase shipping capacity, which was investigated in the SNF CSB Trade Study Report (May 1995).

At the time of delivery of the loaded cask transport rail car to the SNF CSB, the car will be pushed into the Wash Down area. This operation may be performed using either the transport locomotive or the on-site "donkey" engine rail car mover. After the transport car is positioned inside the Wash Down area, it will be decoupled, the locomotive or donkey engine will be withdrawn, and the shield doors closed before the Wash Down process begins.

Transfer of rail car from Wash Down area to Load-In/Load-Out after Wash Down is completed is described in Section 2.4, and is by means of a wire tow rope rail car mover.

Note that details of the MCO transport cask and its radiation levels have not yet been resolved by WHC. Depending on the final configuration and source radiation levels of the loaded transport cask, the rail operation concept described above and the truck operation described below may need to be reevaluated and revised.

### **2.1.2 Road Access**

Access to the site is from Route 4S at the west. A paved entry road to the HWVP site boundary was constructed by the HWVP project. Roadways within the HWVP site are not paved, with the exception of Akron Avenue, which is a two-lane north-south roadway just inside of and parallel to the west security fence. A gravel surface patrol road encircles the HWVP site inside the security fence, and a similar gravel surface site road, 7th Street, bisects the site in an east-west direction approximately 900 feet north of the SNF CSB location. A gravel surface ramp connects the patrol road to the building location just north of the SNF CSB.

For the SNF CSB project, paved access road will be constructed from Akron on the west to the SNF CSB along the extended alignment of the existing access ramp. This will furnish access to the structure by connecting to the existing Route 4S / entry road / Akron Avenue route. All new road construction will be designed to carry a truck with loaded MCO transport cask aboard.

Delivery of loaded MCO transport casks to the SNF CSB by truck will follow the same general sequence as described above for rail delivery, with the exception of the need to transition from pull to push mode. The truck will enter from Route 4S, travel along the HWVP site entry road, turn south onto Akron Avenue, then east onto the SNF CSB access road. At the SNF CSB the truck will back its trailer into the Wash Down area, the tractor will be withdrawn, and the shield doors closed. Similarly to the procedure described above for rail delivery, the Wash Down process will follow.

Transfer of truck trailer from the Wash Down area to the Load-In/Load-Out area must be accomplished just as for the rail car delivery method described above. If this is to be done using the same wire tow rope rail car mover described in Section 2.4, a specially-designed truck trailer will be required that can be aligned using the rails in the floor or otherwise be guided remotely during the transition from Wash Down to Load-In/Load-Out areas.

The comments in Section 2.1.1 above pertaining to the MCO transport cask apply here as well.

## **2.2 ARCHITECTURAL FACILITY LAYOUT**

The building configuration represented in Figures 2-2 through 2-8 shall be considered under eight major areas.

### **2.2.1 Storage Vault Area**

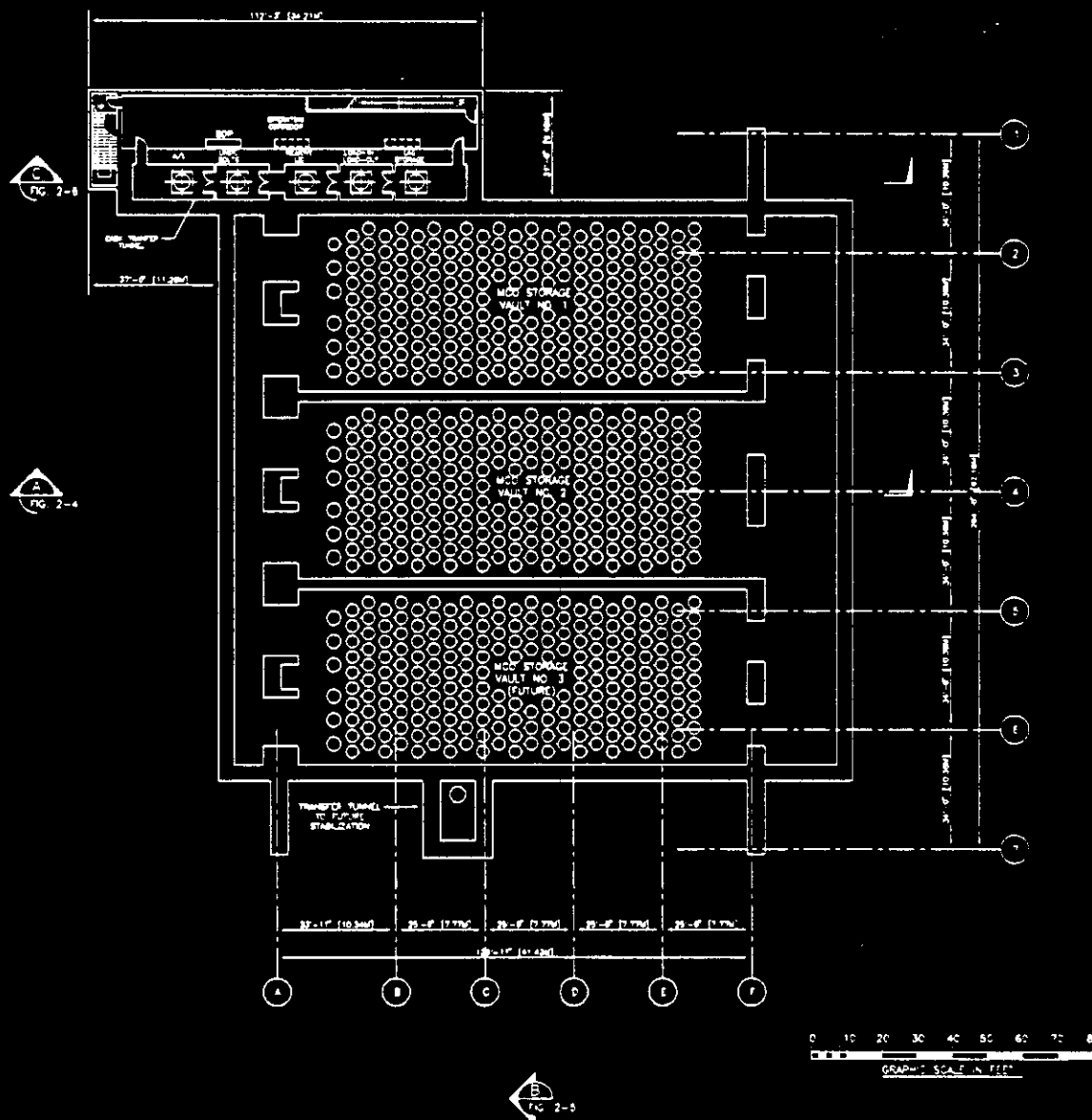
The storage vault area is designed to contain a minimum of 750 multi-canister overpacks (MCOs) stacked two levels high, with





7-7-25

HANFORD PLANT CSB  
 200 EAST AREA DATUM



SNF CSB  
 CONCEPTUAL DESIGN  
 VAULT MAT PLAN

FIGURE 2-3

CAN SAN

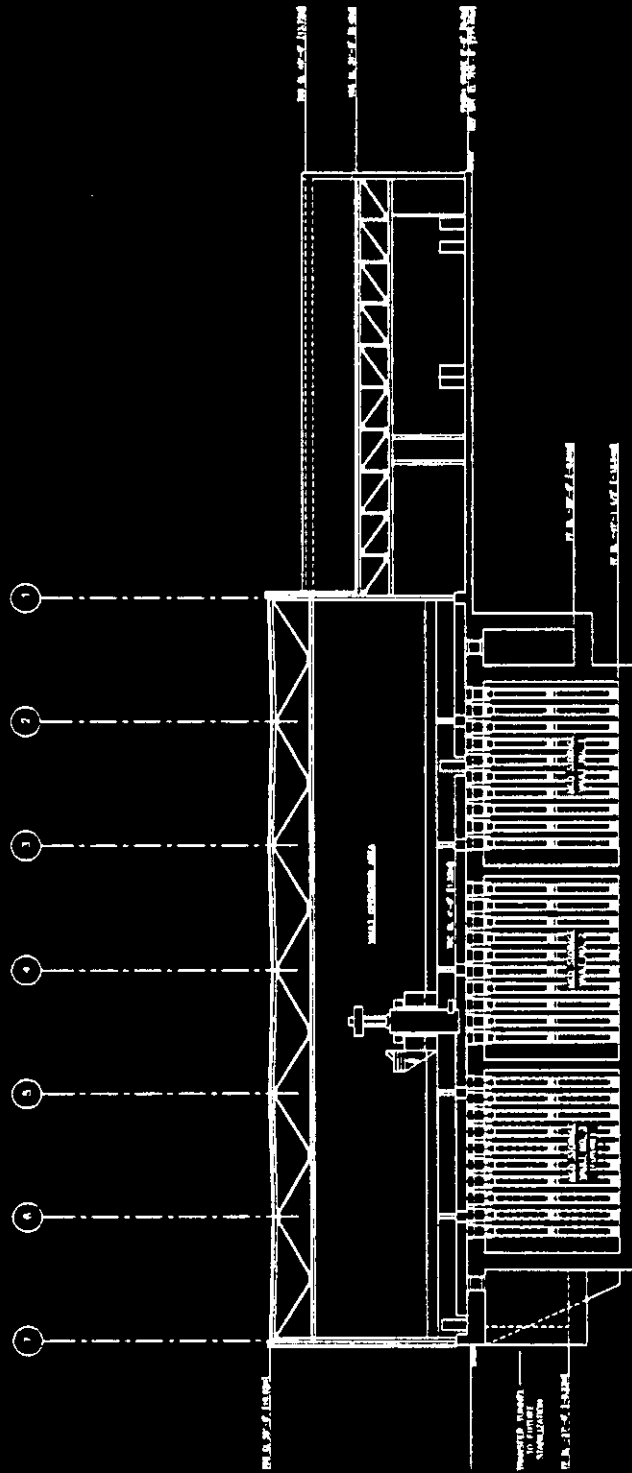
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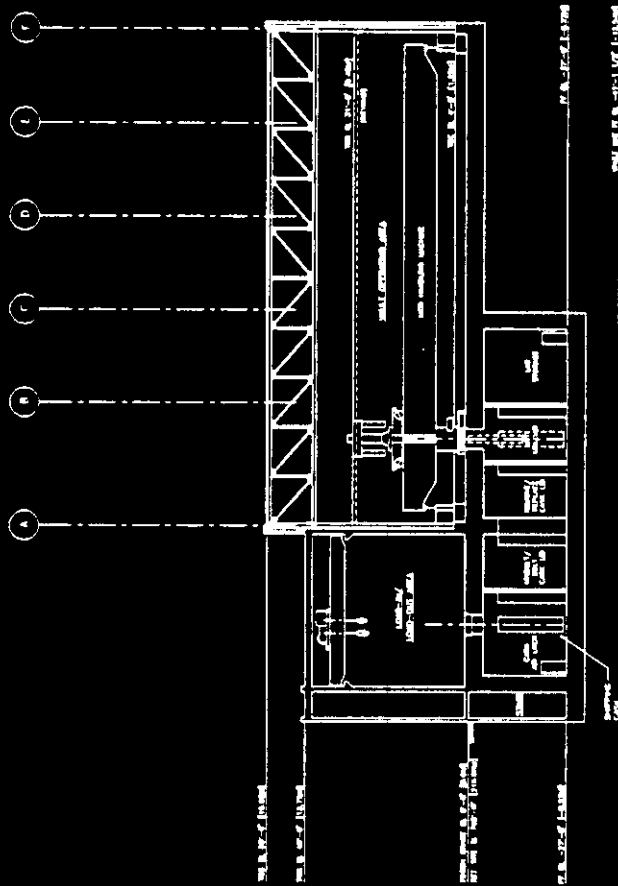


GRAPHIC SCALE IN FEET

SNF' CSB  
CONCEPTUAL DESIGN  
SECTION A

FIGURE 2-4  
C. ANIGAN



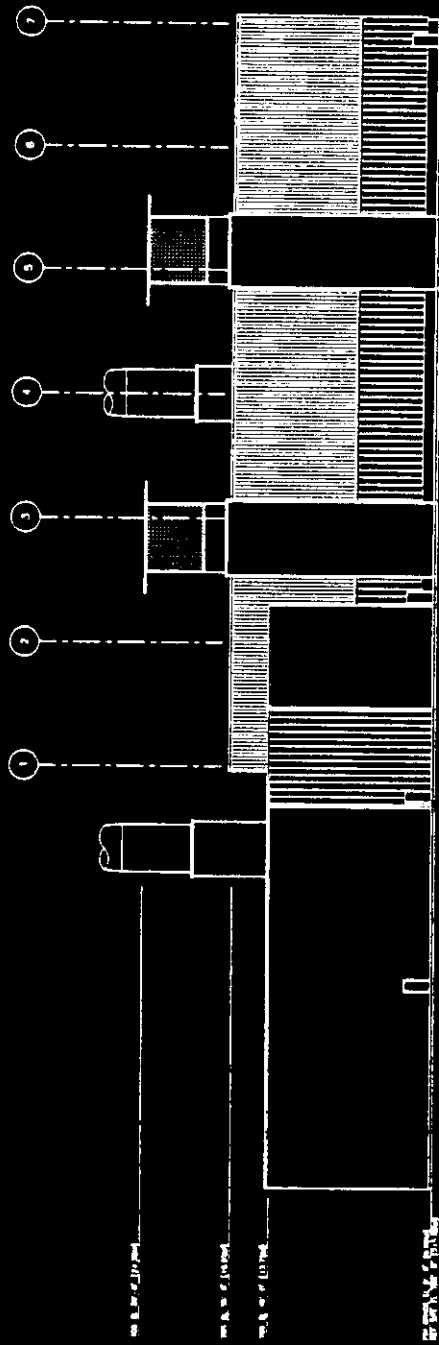


SECTION C  
 1/16" = 1'-0"  
 (SHEET 2-2, 2-3)

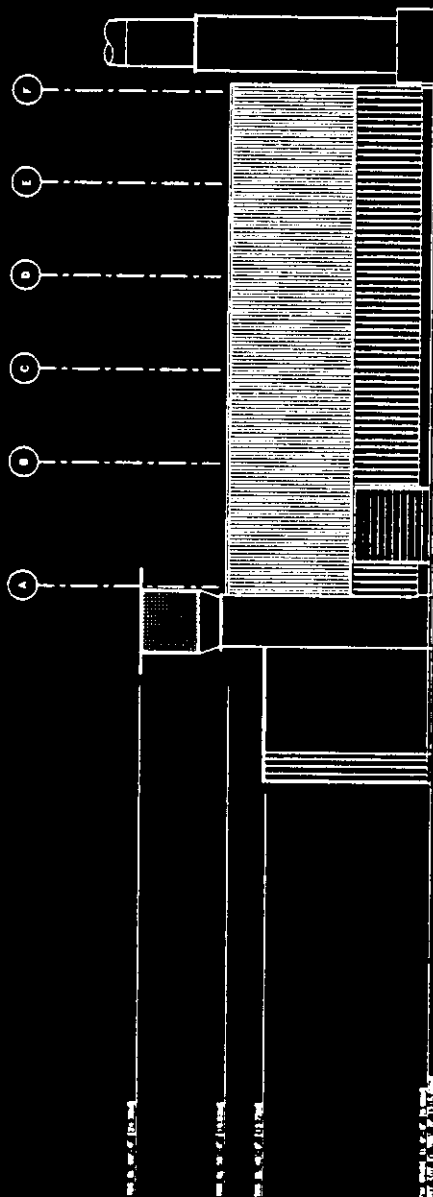
GRAPHIC SCALE IN FEET  
 0 10 20 30 40 50 60 70 80

SNF CSB  
 CONCEPTUAL DESIGN  
 SECTION C

FIGURE 2-6  
 C AIRWAY



WEST ELEVATION



SOUTH ELEVATION

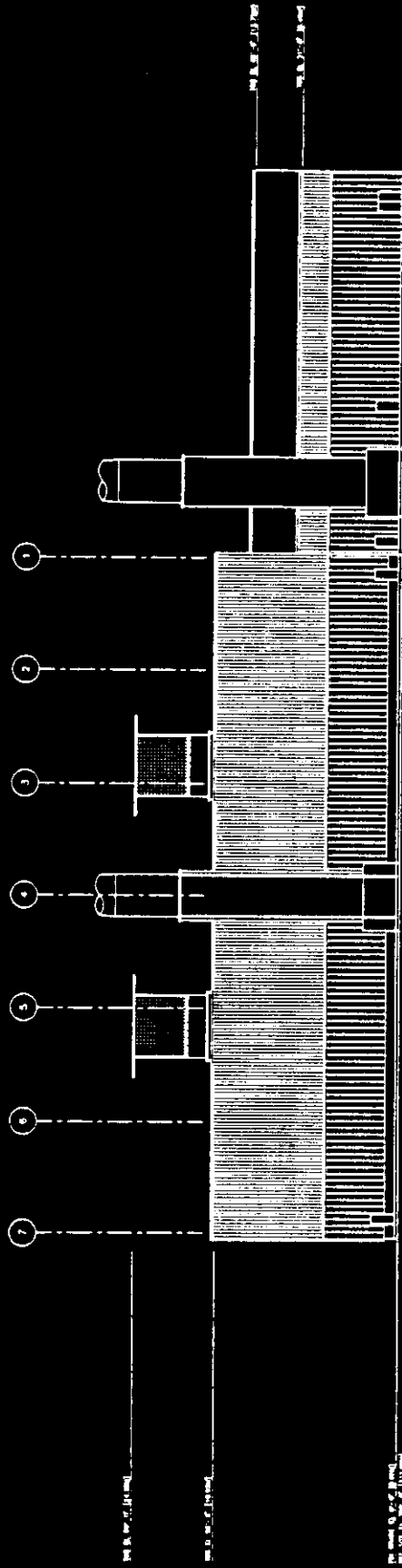


SNF CSB  
CONCEPTUAL DESIGN  
EXTERIOR ELEVATIONS

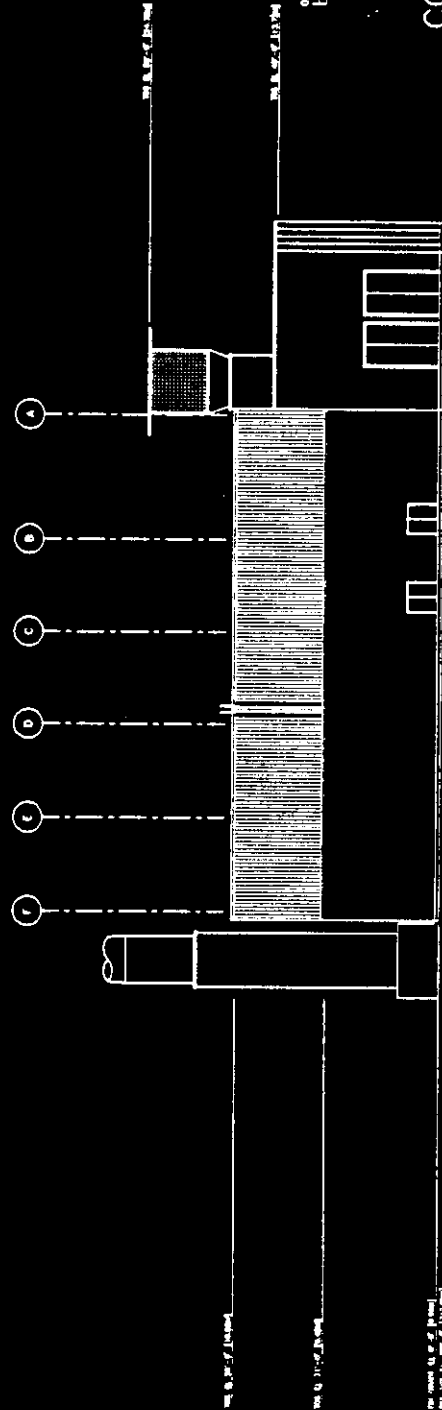
FIGURE 2-7

C. AMERICAN

7-1-95



EAST ELEVATION



NORTH ELEVATION

SNF CSB  
 CONCEPTUAL DESIGN  
 EXTERIOR ELEVATIONS

FIGURE 2-8

C. HANCOCK

7-7-94

impact absorbers below each MCO. The impact absorbers will be designed to decelerate a dropped MCO from 2 feet above the operation deck to the bottom of the storage tube. Since the design contains 220 tubes per vault, only two vaults need storage tubes. Each tube will be designed to support and maintain storage configuration in any abnormal or naturally occurring event. Confinement within the storage tube is required according to DOE Order 6430.1A. The storage vault has natural convective cooling with intake and exhaust plenums to maintain MCO and structural materials within the allowable temperature limits.

#### **2.2.2 Operating Deck Area**

The Operating Deck area contains openings for placement and removal of MCOs in the vault storage tubes. The deck will provide adequate personnel shielding for workers on the deck and structural support for normal loads, abnormal loads, and upset (impact) loads. The Operating Deck area will contain the deck plugs for all three vaults. The operating area deck will be serviced by a crane spanning the east-west direction and capable of handling a bottom loading facility cask. The operating area will have illumination and conditioned air for work space requirements. Confinement will be maintained based on safety analysis results.

#### **2.2.3 Wash Down Area**

The Wash Down Area will receive MCOs by rail car or truck via transportation cask from K-Basin. Once the MCO/Cask is inside the Wash Down area, remotely operated water spray equipment will Wash Down the cask and railroad car or transport truck removing dust and road grime that may have accumulated. After washing down the MCO/Cask the rail car/truck will be pulled into the Load-In/Load-Out by a wire tow rope system.

#### **2.2.4 Load-In/Load-Out Area**

The Load-In/Load-Out Area includes the flexibility to receive MCOs by rail car or conventional truck. An overhead bridge crane will be included capable of handling the MCO and transport cask. Separate from the MCO/Cask Receipt area will be an area for receiving non-radioactive or special shipment materials by truck delivery. An interim new MCO Receipt and Lag Holding area will be included for 10% of the total MCOs. Proximity to a non-radioactive maintenance area will be provided.

##### **2.2.4.1 MCO Receipt and Lag Storage Area**

An area within the non-radioactive truck shipment receipt area for interim holding of 10% of all new MCOs will be provided. An area near the truck receipt area for New MCO Receipt and Lag Storage



will be provided for all MCOs prior to use at the facility or shipment to the 100 Area.

#### 2.2.5 MCO/Cask Service Area

The MCO/Cask Service Area (tunnel) enables MCO handling outside a cask, MCO gas venting, MCO gas sampling, MCO inspection, and MCO transfer from a transport cask to a facility cask. The MCO service area will be connected to the Load-In/Load-Out facility (by airlock if necessary). A shuttle rail cart transports the MCO/Cask within the tunnel. Negative air pressure relative to adjacent areas and exhaust air function with HEPA filters will be provided. Shielded viewing windows will be provided. Provision in the building structural system will be allowed for a future exterior opening for purposes of drying and/or stabilizing spent nuclear fuel.

#### 2.2.6 Support Area

The support area is composed of independent building areas designed for service and support of personnel and equipment.

##### 2.2.6.1 Systems Controls Area

There will be an area for control panels for active electrical and mechanical systems as well as monitoring functions. This is not a separate independent building, but a protected room with such functions.

##### 2.2.6.2 Health Physics Support and Personnel Decontamination Area.

An area for health physics work (not office administration) will be provided including safety showers, personnel decontamination functions, and contaminated change rooms. The area will be located in close proximity to the radioactive activities surrounding the MCO/Cask services and Equipment Decontamination areas.

##### 2.2.6.3 Radioactive Maintenance Area

A radioactive maintenance area adjacent to the operations deck area and next to the non-radioactive maintenance area will be provided. Space and utilities for everyday metal fabrication, welding, and small-part servicing will be provided.

##### 2.2.6.4 Non-Radioactive Maintenance Area

The non-radioactive maintenance area contains normal facility maintenance activities of a non-radioactive condition. Typical services will be HVAC equipment maintenance services, electrical equipment services, and testing equipment maintenance. Metal fabrication, welding, solvent handling, instrument calibration, and

electrical testing will be some of the functions in the area.

#### **2.2.6.5 Waste Handling Area**

An area for purposes of handling radioactive and non-radioactive wastes will be provided. The capability to receive and package liquid and solid wastes for shipment to approved disposal facilities will be included in the waste handling area. Separate zones will be provided within the waste handling area to prevent mixing of wastes.

#### **2.2.7 Mechanical Equipment Area**

This area houses equipment for conditioning and ducting the air throughout the facility. Short-term, skid-mounted equipment will be considered where possible. Natural convection cooling air will be provided to maintain the MCOs at the required temperature.

#### **2.2.8 SC2 Emergency Generator Area**

An area for emergency power generation equipment will be provided to supply power to the SC2 HVAC equipment upon detection of radiation in the operating area. The area will be located east of the SNF CSB, adjacent to the HVAC area. Services and utilities to support the equipment will be included. Each generator (2) will be housed in a steel enclosure. Means of access to the equipment after facility completion will be provided. A local panel for periodic testing will be provided on each generator as well as remote status panels located in the Safety Class electrical rooms.

### **2.3 STRUCTURAL ENGINEERING**

#### **2.3.1 Introduction/Summary**

The structural engineering conceptual design activities consisted of furthering the facility design and cost estimate developed in the CSB Trade Study dated May 1995. Preliminary redesign of the building structural systems was performed due to changes and design development such as: 1) the Operation Area overhead crane was replaced with a MCO/Cask Handling System to mitigate cask drop on to the Operating Area floor; 2) the wet pool MCO transfer area was revised to dry operation; 3) the Wash-Down and Load-In/Load-Out Areas building was changed from metal to concrete due to shielding requirements; and 4) the Support Area for offices, mechanical, electrical and waste functions was reconfigured.

The seismic design criteria, both for new DOE Order 5480.28 and for NRC Equivalency, remain an open issue. A brief review of existing literature and methodology for improving durability and predicting the service life of concrete structures has determined that the existing CSB vault design and material of construction need

improvements to achieve the desired 200 year design life. A brief evaluation of the IFC Kaiser white paper titled "Construction Innovations and Schedule for the CSB" was made and documented in Conference Note No. CN-1055, dated June 14, 1995. Concepts for pre-assembly, modularization, and pre-casting were proposed as means to meeting the aggressive construction completion milestone. We propose that cost/benefit studies be made to assess the overall impact, including effects on the engineering schedule due to the redesign of the Vault structure.

### 2.3.2 Design Criteria

The conceptual design of the SNF CSB facility is in conformance with the specifications, standards, criteria, and codes given in the following documents:

- A. HWVP Project Design Guide, Section 10, Structural and Civil Design Basis, Revision 02.
- B. WHC-SD-SNF-FRD-014, Rev. A, dated May 17, 1995, titled "Draft Performance Specification for the Spent Nuclear Fuel Canister Storage Building, Project 97A-EWW-379".

The seismic criteria issue, stated in the Concept 2D CSB Trade Study Report dated May 1995, remains unresolved. The conceptual design for the Safety Class (SC) 1 Structures, Systems, and Components (SSC) has been based on Design Basis Earthquake (DBE) anchored at peak ground acceleration (PGA) of 0.35g as per HWVP Change Request No. 1025. In a recent meeting on seismic design criteria (see Conference Note CN -1056 ) there was a consensus that DOE Order 5480.28 and associated standards ( DOE-STD-1020, 1021, 1022, 1023 & 1024 ) should be implemented on this project. WHC has developed the following correlation of seismic anchor values:

| Current Correlation<br>(SDC 4.1 Rev 12, UCRL 15910) |               |         | New DOE 5480.28 Correlation<br>(New Seismic Hazard Study, DOE-STD-1020-94) |                          |         |
|-----------------------------------------------------|---------------|---------|----------------------------------------------------------------------------|--------------------------|---------|
| SC                                                  | (Reactor)     | = 0.25g | PC-4                                                                       | (Reactor)                | = 0.37g |
| SC-1                                                | (High Hazard) | = 0.20g | PC-3                                                                       | (Safety Class)           | = 0.19g |
| SC-2                                                | (Mod. Hazard) | = 0.12g | PC-2                                                                       | (Safety Significant)     | = 0.13g |
| SC-3                                                | (Low Hazard)  | = 0.12g | PC-1                                                                       | (Occupational Safety)    | = 0.09g |
| SC-4                                                | (General Use) | = 0.09g | PC-1                                                                       | (General Use)            | = 0.09g |
|                                                     |               |         | PC-0                                                                       | (No Safety Significance) | = 0.00g |

**Note:** The above new correlation contained in document WHC-SD-GEN-RD-30011 has not been approved as Hanford Site Standard Design Criteria.

Per DOE criteria SNF CSB is considered a non-reactor nuclear facility. The WHC Preliminary Safety Evaluation (PSE) document WHC-SD-SNF-PSE-001 has established all phases of the Spent Nuclear Fuel Program (SNFP) as Hazard Category (HC) 2 in accordance with DOE 5480.23 and DOE-STD-1027. Per DOE-STD-1021, SSCs performing safety function are classified as Performance Category (PC) 3. Therefore, for SC-1 and PC-3 the PGA is 0.19g per the new criteria and seismic hazard curve.

However, the SNF CSB Draft Performance Specification also requires the design to meet Nuclear Regulatory Commission (NRC) Equivalency and 10 CFR 72 requirements along with meeting DOE Orders and Standards. This means that both sets of requirements are to be met. Per 10 CFR 72.102 the DBE must be equivalent to the safe shutdown earthquake (SSE) for a nuclear power plant as developed per criteria given in 10 CFR 100, Appendix A. Ground motions and response spectra conforming to these criteria need to be developed and made available prior to start of Detailed Design.

Another factor that may impact the design is the lower damping values specified in NRC Regulatory Guide (RG) 1.61 as given in Table 2-1 below. Lower damping values will yield higher seismic response for a given ground motion.

Table 2-1  
Seismic Damping Values

| Material of Construction | DOE-STD-1020-94<br>(Post Yield ) | NRC RG 1.61 |
|--------------------------|----------------------------------|-------------|
| Equipment and Piping     | 5                                | 3           |
| Welded Steel             | 7                                | 4           |
| Bolted Steel             | 10                               | 7           |
| Prestressed Concrete     | 7                                | 5           |
| Reinforced Concrete      | 10                               | 7           |

### 2.3.3 Structural Systems Description

Refer to Figures 2-2 through 2-8 for the structural systems described below.

#### 2.3.3.1 Storage Vaults/Operating Shelter

The CSB MCO storage area is an approximately 180' x 165' x 48' deep below-grade reinforced concrete structure consisting of three vaults with top slab operating deck, covered by a structural steel operating shelter. The MCOs will be stored in vaults 1 & 2. Vault 3 is intended for a future mission. The partition walls between

the vaults were originally 3' thick but now the wall between vaults 2 & 3 will be 3'-6" thick to meet shielding requirements. The foundation mat is 5'-8" thick at its high point and serves as a floor for supporting the storage tubes. The convective cooling air is received through two 17' x 18' x 22' high weathering steel (e.g., CORTEN) intake structures supported on two 20' x 15' x 56' high reinforced concrete intake towers. The hot air is then exhausted through a 184' high weathering steel (e.g., CORTEN) Exhaust Stack No. 1 supported on a 10' high reinforced concrete ring base.

The operating deck above the storage vaults is a 5' thick reinforced concrete slab supporting shield plugs and plug sleeves for access to the storage tubes. The operating floor areas extending beyond the storage vaults in the north/south direction are 5'-0" thick and are supported by wing walls to provide support for the columns at column lines 1 and 7. The storage vaults are designed using Safety Class 1 design basis. The structural steel operating shelter (approximately 204' x 136' x 56' high) supports the travelling bridge Shielded Cask/MCO Handling Machine and provides shelter for the operating area. The vaults and the operating shelter structure are designed for Safety Class 1 (Performance Category (PC) 3) design basis. The operating shelter structure cladding system is designed as Safety Class 2 (Performance Category (PC) 2).

#### 2.3.3.2 Cask Transfer Tunnel

The MCO/Cask Transfer Tunnel is found in the MCO/Cask Servicing Area and is connected to the northernmost storage vault. The tunnel is approximately 110' x 30' x 35' deep with tunnel walls approximately 4'-6" thick where shielding is required and 2'-0" thick where shielding is not necessary. The tunnel provides shielding from the un-shielded MCO's during their transfer from the Load-In/Load-Out facility to the storage vaults. Access for maintenance is provided through an operations corridor adjacent to the tunnel. The transfer tunnel is to be designed as a Safety Class 2 (PC 2) structure.

#### 2.3.3.3 Wash Down and Load-In/Load-Out Areas

The Wash Down and Load-In/Load-Out Areas are above-grade cast-in-place reinforced concrete shield structure measuring approximately 168' long x 46' wide x 45' high. The walls and roof are 2' thick to meet shielding requirements. The foundation mat/floor is 5' thick and provides stability against overturning for the East-West seismic loads. The floor is equipped with flush mounted rails to allow either truck or rail access. In the Wash Down Area a floor drain collection and holding system is provided to collect and control possibly contaminated wash water. The Load-In/Load-Out Area is equipped with a 40 ton bridge crane for transferring the

transport casks from the truck or rail car to the MCO/Cask Servicing Area. These areas are designed as a Safety Class 2 (PC 2) structure.

#### 2.3.3.4 Support Area

The Change Room / Mechanical Area, HVAC Area and Waste Handling Area are enclosed by an approximately 130' x 117' x 31' high steel building with a roof truss and column system supported on spread footings. Cast-in-place concrete shield walls are provided in the radioactive maintenance, Wash Down holding tank areas and on the north exterior face of the Mechanical Area and HVAC Areas. These areas are designed as a Safety Class 2 (PC 2) structure.

#### 2.3.3.5 Emergency Generator Enclosures

Steel enclosures with integral generator/enclosure foundations are provided for two emergency generators. These enclosures and foundations are designed as Safety Class 2 (PC 2) structures.

#### 2.3.3.6 Exhaust Stack No. 2

The carbon steel stack is 120' high with an 8'-6" diameter at the base and 3'-4" diameter at the tip. The stack is designed as a Safety Class 1 (PC 3) structure for the design basis earthquake and wind due to its proximity to the vault structure.

#### 2.3.2.7 Stabilization Transfer Tunnel

A below-grade transfer tunnel located on the south side of the storage vaults will be provided for access to the future stabilization facility. Construction would be similar to the MCO/Cask Transfer Tunnel. The transfer tunnel is designed as a Safety Class 2 (PC 2) structure.

#### 2.3.3 Design Life

Section 3.2.2.1.1 of the Draft Performance Specification WHC-SD-SNF-FRD-014 (Rev. A) requires the structures of SNF CSB to have a design life of 200 years and 40 years for systems and components. Little data relative to the historical performance of modern concrete is available (~100 years), so that various mathematical models and test data have been used to predict concrete material properties over long time periods. These models have been reviewed in NUREG/CR-5542 and are used for estimating the design life of the SNF CSB concrete structures with the soil and concrete properties used in the design. Detailed evaluation is given in Appendix III.

A preliminary evaluation of concrete exposed to various environmental, material, and service-related conditions has indicated that the sulfates and chlorides in the site soils are the

predominant factors influencing the design/service life of the concrete structures below grade. As stated in NUREG CR-5542, it is apparent that available models for predicting service life of concrete are limited in terms of scope and validity. Models for predicting concrete longevity for combined or coupled effect of all processes working simultaneously are not available. Given the current state of model development, the classical conservative analysis mode of calculations may be more appropriate. It should also be recognized that low moisture content in the soils, arid climate, and deep water table will slow the rate of chlorides and sulfates attack.

Cracking of the concrete facilitates degradation by other processes, and it is very difficult to predict where and when cracks will appear. Even a small crack can change the transport properties of concrete by orders of magnitude. Even if all the cracks have been sealed and no new crack formation is expected, it is difficult to clearly demonstrate in a performance assessment that no new cracks will form. Nuclear power plants have typically been designed for a service life of 40 years, and studies on concrete aging relative to their life extension (NUREG/ CR-4652) have shown to increase the service life up to a maximum of 25 years.

Options that could be considered for increasing the design life are: 1) Washing the site soils used for backfill to remove harmful chemicals; 2) providing an additional 1 to 2 inch layer of sacrificial concrete on surfaces in contact with soils; 3) use Type V sulfate-resistant cement; 4) provide design margins; and 5) provide a sulfate and chloride resistant coating system. All these options will add to the facility cost. In our opinion, with the current design and maintaining quality in construction, it is possible to achieve 75 to 100 years of design life without significant increase in the facility cost. An expert in concrete chemistry and technology will need to be consulted, preferably during Advanced Conceptual Design, to develop recommendations that will improve concrete durability. Samples of various concrete mix designs should be subjected to accelerated laboratory tests to determine degradation rate when exposed to the chemicals expected to be found in site soils.

## 2.4 MECHANICAL ENGINEERING

### 2.4.1 Introduction/Summary

The mechanical components' primary functions are for handling and servicing operations associated with the transportation casks and MCOs from receipt in the Wash Down area to placement in the storage tubes. During all operations the system will provide physical protection and support for the MCOs while maintaining personnel radiation exposure levels within ALARA limits.

The major changes made during Conceptual Design from the Trade Study Concept 2D are: 1) all operations on transport casks loaded with MCOs will be remote, not contact; 2) servicing of the casks and MCOs will be done in a dry tunnel, not in a pool; and 3) the SNF CSB facility cask will be permanently mounted on the trolley of the bridge crane servicing the canister storage operating area and not be lifted with a hoist.

#### 2.4.2 Performance Objectives and Design Decisions

- 2.4.2.1 The maximum allowable MCO temperature is 400 °F.
- 2.4.2.2 Casks from K-Basin must be handled at the rate of 2 per day.
- 2.4.2.3 The MCOs will be shipped from K-Basin with the vent valves closed. The vent valves will be opened during MCO servicing operations in the cask transfer tunnel.

When an MCO passes through monitoring and servicing, the vent valve(s) on the MCO will be opened remotely in the cask transfer tunnel and normally left open. The normal rate of hydrogen generation is not sufficient to create a flammable mixture in the tube space. If an MCO is generating an excessive amount of hydrogen, the design allows the MCO to be blanketed with an inert gas and placed in the tube for staging with the MCO vent valve(s) closed. Any MCO that is stored with the valves closed must be returned for servicing before the pressure increases to the design limit. It is assumed that a cask will contain all gas vented from its MCO in the event that the MCO relief device opens.

- 2.4.2.4 The operating floor, tubes, and plugs are Safety Class 1, based on Fluor Daniel safety class determinations. As a result, all other items capable of damaging Safety Class 1 items in an accident (e.g., the operating area crane and MCO Handling Machine (MHM)) shall be designed not to fall during Safety Class 1 DBAs. In addition, items that support a single MCO will be designed not to breach the MCO (e.g., by dropping) during Safety Class 2 DBAs.
- 2.4.2.5 An individual outside the building shall be exposed to no more than 0.05 mrem/hr from the facility. A 40 hr/week employee will not be exposed to more than 0.2 mrem/hr.



## 2.4.3 Mechanical and Systems Descriptions

### 2.4.3.1 Cask Handling System General Description

The Cask Handling System's main function is to receive transport casks containing MCOs from K-Basin, deliver the MCOs to the operating area, and ship empty casks and clean MCOs back to K-Basin. In addition, the system will provide overpack containers to the operating area and facilities for servicing MCOs. During receiving, the system provides support for the casks and radiation shielding to protect personnel. The Cask Handling system includes the unloading area cranes, a cask sampling device, various remote rigging fixtures, shielding doors and hatches, remote tools for removing the cask lids and servicing the MCOs and cask transfer carts. Equipment is listed in Appendix II.

### 2.4.3.2 MCO Handling System General Description

The MCO Handling System's main function is to transport MCOs inside the operating area, as related to the staging and storage of MCOs and MCO overpacks. During transportation, the system provides support and physical protection for the MCOs and radiation shielding to protect personnel. The MCOs are transported to:

- 1) bring unstabilized MCOs from the MCO/Cask Transfer Tunnel into the operating area and placing them in storage tubes with impact absorbers;
- 2) move MCOs from storage tubes to the tunnel for servicing during the beginning of staging;
- 3) return serviced MCOs from the tunnel to the storage tubes;
- 4) move failed MCOs from storage tubes to the tunnel for overpacking during staging;
- 5) return overpacked MCOs from the tunnel to overpack storage tubes;
- 6) remove unstabilized MCOs from storage tubes to send them to the Stabilization Facility; and
- 7) return stabilized MCOs back to the storage tubes.

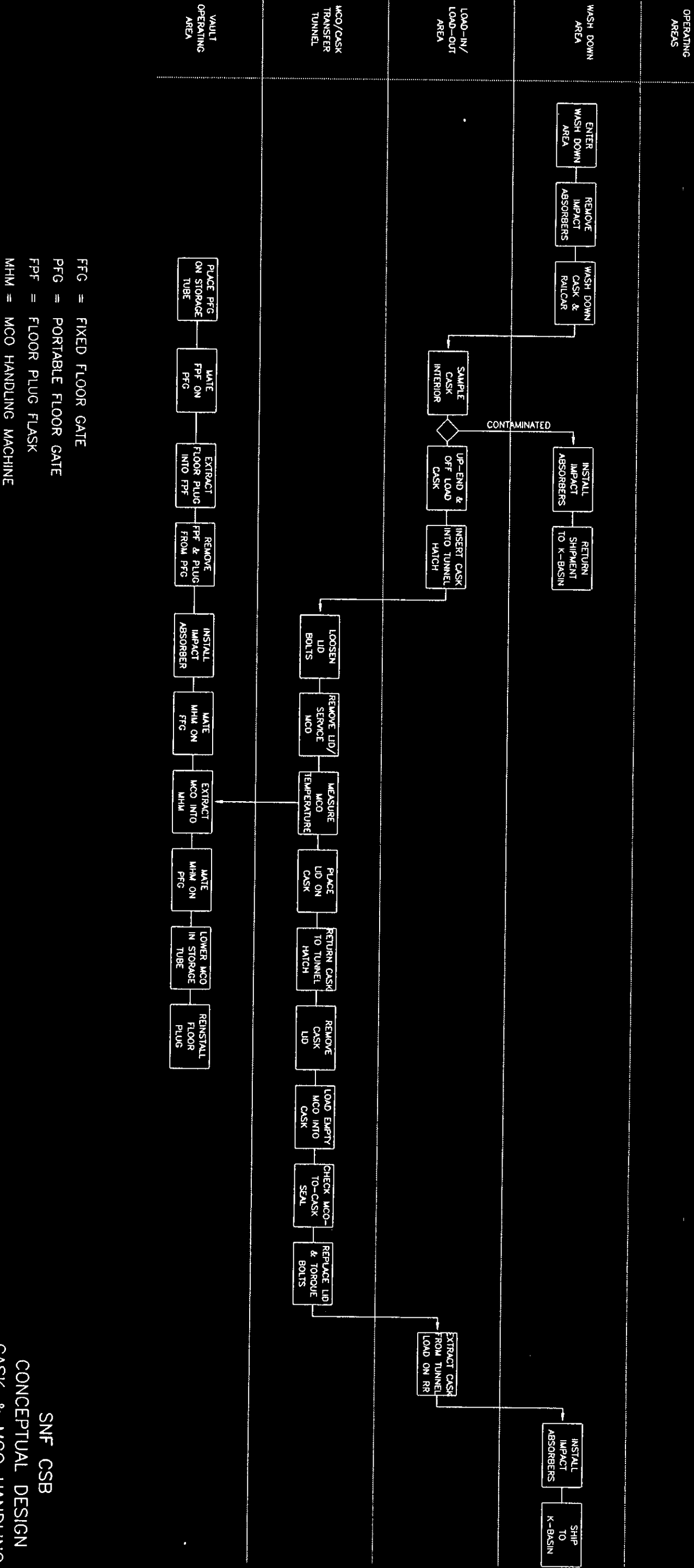
The MCO Handling system includes the overhead bridge crane for the operating area, MHM and impact absorbers for the MCOs. The MHM is a shielded, bottom-loading handling cask that is rigidly suspended from the trolley of the crane. The crane and MHM function together and are operated as a single unit. Figure 2-9 describes the MCO/Cask handling process.

### 2.4.3.3 System Descriptions

#### 2.4.3.3.1 Wash Down Area

This area will be remotely operated when a loaded MCO is present, even when it is in the transportation cask. All other operations, including maintenance will be by contact.

The outside doors for the railroad cars and trucks will be 5" thick steel shield doors. This area can accommodate two rail cars or trucks (or combinations thereof) in parallel. A donkey engine will be used to spot the rail car containing the transportation cask in



FFG = FIXED FLOOR GATE  
PFG = PORTABLE FLOOR GATE  
FPF = FLOOR PLUG FLASK  
MHM = MCO HANDLING MACHINE

SNF CSB  
CONCEPTUAL DESIGN  
CASK & MCO HANDLING  
BLOCK FLOW DIAGRAM  
FIGURE 2-9

CAHIGAN 7-21-95

the Wash Down area. After the engine has placed the rail car, the engine will be removed and the powered shield doors will be closed. Remote operation will be viewed through two shield windows located in the east side of the room.

The Wash Down area will have a 5 ton under-hung bridge crane. This crane will be used to remove the impact absorbers from the transportation cask, including removal of bolts or other holding devices for the impact absorbers. The impact absorbers will be placed on the rail car.

The 5 ton crane will be used to connect the cask sampling equipment to the nozzles and valves. This equipment will sample the annular and head space between the cask and MCO to determine the integrity of the MCO. Any anomalies found during this verification will result in the re-installation of the impact absorbers and return of the shipment to K-Basin.

An array of fixed nozzles to wash road dirt off of the rail car and transport cask are located in the Wash Down area. This washing will occur after the impact absorbers have been removed.

This area will also contain spray/wash lances for cleaning other equipment when a loaded cask is not present.

A sump is located within the Wash Down area for collecting the wash water. A sump pump will be used to transfer the water to a holding tank located in an adjacent room.

The Wash Down room has one external personnel (5" steel shielding) door in the west wall and two internal personnel (4" steel shielding) doors in the east wall going into adjoining corridors.

#### 2.4.3.3.2 Load-In/Load-Out Area

This area is located adjacent to and south of the Wash Down area. Access from the Wash Down area is through 4" thick steel shielding doors. These doors allow contact work in the Wash Down area when a loaded transport cask is in the Load-In/Load-Out area or vice-versa.

The rail car is moved from the wash area to the Load-In/Load-Out area with the rail car moving device. This device will be a wire tow rope system located in the floor between the rail cars. This tow rope will be attached to the rail car by the 5 ton crane. This device will be able to move rail cars/trucks in either direction. The Load-In/Load-Out area has a bridge crane with a 40 ton main and a 10 ton auxiliary hoist. The crane, with an impact wrench, will unbolt the cask from the rail car and remove attachment hardware. The crane, with a yoke, will upright and lift the transport cask. A power shielded cask entrance hatch will be used to gain access to

( the MCO/Cask Transfer Tunnel from the Load-In/Load-Out area. When this hatch is closed and there are no loaded MCOs in the Load-In/Load-Out area, contact work may be performed. The crane will lower the transport cask into the tunnel. Remote operation will be viewed through two shield windows located in the east side of the room.

The Load-In/Load-Out room has one external personnel door (5" steel shielding) in the west wall, one internal personnel door (4" steel shielding) in the east wall going into an adjoining corridor and one internal equipment/personnel steel shielding double door (4" x 6' x 7') in the east wall going into an adjoining corridor.

In the south end of the Load-In/Load-Out area is a clean MCO/MCO overpack/cask storage rack. This rack will be used to store 28 new clean MCOs before loading into the transport cask, one MCO overpack and two transport casks ready for return to K-Basin. The empty MCOs will be lifted with the crane and the MCO handling device. This device will be an expanding mandrel. The empty MCO will be loaded into the transport cask through the cask entrance hatch before the cask is removed from the tunnel.

#### 2.4.3.3.3 Non-Radioactive & Radioactive Maintenance Areas

( These maintenance areas will contain small shop equipment such as (but not limited to) drill press, pedestal grinders, welders (MIG, TIG and Gas), band saws, small manual hydraulic presses, benches, pipe threaders, and power and manual hand tools. The Radioactive Maintenance Area will have a coating to facilitate decontamination of the room.

#### 2.4.3.3.4 Waste Handling Area

This area will be used to sort and package solid waste for transfer to other facilities for compaction and disposal, some of which may be radioactive waste in barrels. A stub shadow shield wall (maze) will be used to protect personnel in the Waste Handling Area.

#### 2.4.3.3.5 Entrance Shield Doors

There are two entrance shield doors on the north end of the building to provide shielding of personnel in the building when a rail car or truck with a loaded cask is approaching the building or awaiting movement into the wash area. These doors are 5" x 6' x 7' steel.

#### 2.4.3.3.6 MCO/Cask Transfer Tunnel

( This tunnel is on the north side of the north vault wall. Loaded transportation casks are placed in the tunnel from the Load-In/Load-Out area. When the casks are put into the tunnel they are

placed on a railed transfer cart. The transfer cart will have two fully redundant drive systems. The transfer cart will index at preprogrammed locations that match the remotely operated devices.

The first station in the tunnel is an airlock where the cask is loaded onto the cart. The second station (Undo Bolts) is separated from the first by a set of HVAC doors. The lid bolts are loosened here with a remotely operated device which will pivot on an arm, lower and loosen the bolts. The third station (Remove Lid) is separated from the second by a shield door, which will allow maintenance work on one end or the other with a loaded cask on the opposite side. At this station, the cask lid is removed and the MCO is serviced. The cask lid will be removed by a jib crane with a grapple (or other such device compatible with the cask lid). The lid will remain on the jib crane until the empty cask exits the tunnel, at which time it will be placed on the cask for removal. At this third station, the MCO can be vented and purged. This service station will be equipped with vent and purge lines and will open and close the valves on the MCO.

The fourth station is where the MCO is unloaded from the cask. This is done by the MHM located in the canister storage operating area above.

Remote operations within the tunnel are viewed from shielding windows at stations 1, 2, and 3 and from CCTV at station 4. Station 4 uses CCTV rather than shield windows because of the shielding requirements when the MCO is removed from the cask.

There are two shield doors for entering the tunnel for maintenance work. On the west end is a 4" x 3' x 7' steel door and on the east end is an 8" x 3' x 7' steel door.

The empty transportation cask is returned to the remove lid station where the lid is placed on the cask and then the cask is returned to the hatch underneath the Load-In/Load-Out area where it will be fitted with a new empty MCO and its lid replaced before being returned to K-Basin. All other handling operations associated with the returning cask will be by contact means and include checking of the sealing arrangement at the top of the cask.

Extra cart spaces at each end of the tunnel will enhance flexibility of operations in the tunnel.

#### 2.4.3.3.7 Canister Storage Operating Area

This area is located above the vaults and contains the following equipment for handling the MCOs as follows.

#### 2.4.3.3.7.1 Fixed Floor Gate

This floor gate is located in the canister storage operating area and is the exit hatch from the MCO/Cask Transfer Tunnel for the MCO.

The MHM cask is placed on the fixed floor gate, the gate opens (along with the gate on the MHM) to allow a grapple and hoist in the MHM to remove the MCO from the transport cask and place it in the MHM cask. Interlocks on the fixed floor gate and the MHM will not allow the gates on the floor gate or on the MHM to open unless the two are properly engaged. Additional interlocks will not allow the MHM to be removed from the floor gate unless the gates on the floor gate and the MHM are closed. This fixed floor gate provides shielding for personnel in the canister storage operating area from MCOs in the tunnel. The opening in the gate is only large enough for the MCO and overpack to pass through.

#### 2.4.3.3.7.2 Portable Floor Gate

The portable floor gate is located in the canister storage operating area. The portable floor gate will be moved from one storage tube to another by the 25 ton hoist on the MHM.

The floor gate is placed over the floor plug with the gate in the closed position. The floor plug flask is placed on the floor gate, and the gate is opened to allow a grapple and hoist in the plug flask to remove the floor plug. Interlocks in the portable floor gate and the floor plug flask prevent the gate from opening unless the two are properly engaged. Additional interlocks will allow the removal of the plug flask only if the gate is closed.

After removal of the plug, the MHM cask is placed on the floor gate for inserting the MCO into the tube. This procedure is similar to operation of the fixed floor gate except in the reverse order. Similar interlocks prevent the gates from being opened when the MHM separates from the floor gate. Replacing the floor plug is similar to the reverse of the removal.

The opening in this floor gate is large enough for the overpack floor plug to pass through.

#### 2.4.3.3.7.3 Floor Plug Flask

The floor plug flask is used to remove floor plugs (MCO storage tube plugs and overpack storage tube plugs). The flask contains a grapple for grasping the plug and a hoist for lifting. Refer to the portable floor gate section above for operation. The flask has shielding in the top and lower flange for protection when the portable floor gate is open and the plug is being removed or installed in the flask.

#### 2.4.3.3.7.4 MCO Handling Machine (MHM)

Off-loading and inserting the MCO into storage tubes involves a shielded bottom loading handling cask which has its own dedicated grappling and hoisting systems and is rigidly mounted on the trolley of a conventionally-designed 110-ton overhead bridge crane. This combination handling cask and bridge crane MHM operates in the CSB Operating Area and has been dedicated to handle the MCO.

A 25-ton cantilever monorail mounted on the bridge will do other lifting.

The MHM's bridge and trolley are used to accurately place the cask over a predetermined location such that its grappling system may be activated to raise or lower an MCO into or out of its shielded interior. The function of the portable shielding gate is to provide radiation shielding from an MCO in transition or the MCOs already placed in the Storage Tubes.

#### 2.4.3.3.7.5 Floor Gate & Floor Plug Cask Yoke

A single yoke will be used to handle the portable floor gate and the floor plug cask.

#### 2.4.3.3.7.6 Storage Tubes

There are three underground vaults as shown in Figure 2-2. Two of the vaults contain 220 MCO storage tubes each with six overpack storage tubes in one vault and five in the other. These tubes are similar to the HWVP CSB except that the weathering steel (e.g., CORTEN) material has been changed to carbon steel. The third vault will not have storage tubes but will contain floor plugs & embeds on the operating deck.

#### 2.4.3.3.7.7 Impact Absorbers

Since 750 MCOs are to be stored only 375 of the MCO storage tubes will contain impact absorbers. All eleven of the overpack storage tubes will contain impact absorbers.

An impact absorber in the bottom of the storage tube will impart about 20 Gs on the MCO when it is dropped from its upper most position in the MHM cask to the bottom of the MCO storage tube. The impact absorber for the upper MCO in the storage tube will be shorter than the bottom one but will impact about the same G-load.

#### 2.4.3.3.7.8 Floor Plugs and Embeds

The floor plug embeds will be the same as for HWVP CSB except that the weathering steel (e.g., CORTEN) material will be changed to carbon steel.

The floor plugs will be the same as they were for HWVP CSB except that the weathering steel (e.g., CORTEN) material will be changed to carbon steel and the 18" of insulating concrete will be eliminated. This will reduce the height of the plug by the same amount.

#### **2.4.7 Open Issues**

- 2.4.7.1 Interface information is needed for items to be designed by others. For example, the cask weight, dimensions, trunion locations, loading position on rail car or truck, and center of gravity are not fully determined.

### **2.5 HVAC ENGINEERING**

#### **2.5.1 Introduction/Summary**

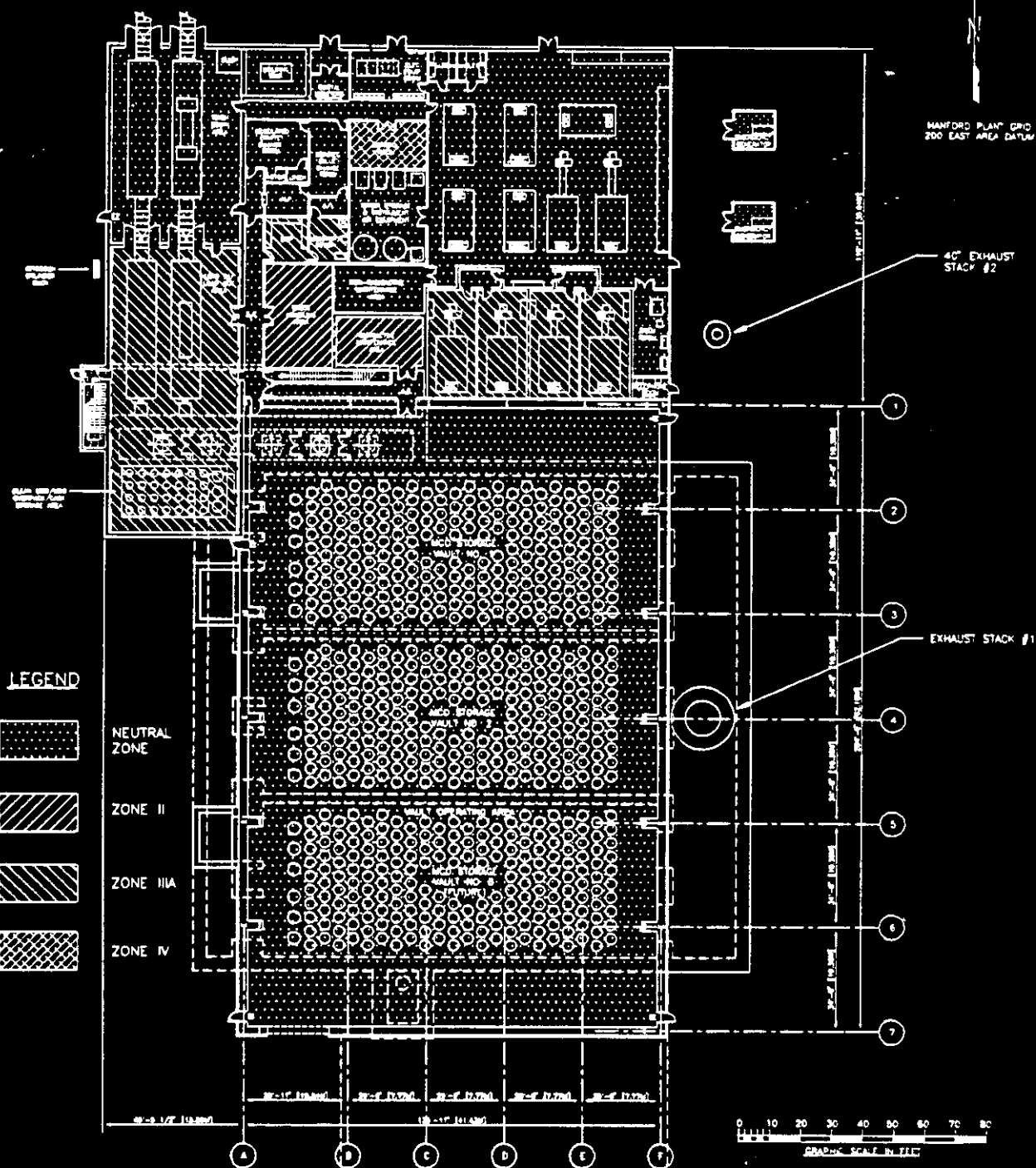
The HVAC system for the SNF CSB consists of independent passive ventilation for the two storage vaults storing Multiple Canister Overpacks (MCOs) of SNF. This system operates based on the "chimney effect" principle, drawing outside air through two elevated intake structures by buoyancy forces due to the density difference between the hot air inside the vault and the cooler air outside. Exhaust air exits through an elevated stack, Stack No. 1. Above the vaults is the Operating area, which is cooled to approximately 85°F during normal operation and has a backup outside air purge for hydrogen and krypton dilution. Redundant HEPA-filtered exhaust trains connected to the backup generators are "on demand" systems initiated by radioactive particle sensors.

The MCO/Cask Removal vault has a continuous exhaust system. Exhaust from these areas passes through two stages of HEPA filtration prior to discharge to the atmosphere. This system is also connected to the backup generators.

Areas of the Load-In/Load-Out area having the least potential for contamination are provided with a HEPA filtered recirculating exhaust system connected to the site power only. The rest of the areas do not have potential for contamination, and as such have no confinement provisions.

The SNF CSB is analyzed and zoned (as shown on Figures 2-10 and 2-11), based on the potential for contamination. Considered in these evaluations are contamination potentials dictated by the process operation and Design Basis Accident scenarios. HVAC systems and/or components are assigned safety classes according to the system or component safety function, (e.g., in providing and maintaining confinement during normal and DBA conditions of operation).





SNF CSB  
CONCEPTUAL DESIGN  
VAULT OPER FLOOR PLAN  
HVAC VENTILATION ZONES  
FIGURE 2-10

P. JOHNSON

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6-35-95

The HVAC system design in the Feasibility Study, Concept 2D, required the use of a refrigerated system for cooling the MCOs to meet the maximum allowable temperature of 100°F.

Relaxation of the maximum MCO temperature to 400°F allows the application of a passive ventilation system which the current design now reflects.

## 2.5.2 Vault Passive Ventilation System Description

### 2.5.2.1 System Description

The vault passive ventilation system provides cooling of the MCOs stored in the CSB vault. The radioactive decay heat generated by the MCOs will be removed by the passive ventilation air which enters the vault through two intake structures, down through an intake plenum, directed across two underground vaults through a network of vertical storage tubes, into the exhaust plenum, and is exhausted to the atmosphere through the exhaust stack. This system is Safety Class 1 and is designed to operate following all DBAs and to maintain the MCO temperature below the maximum allowable limit of 400°F.

### 2.5.2.2 Originating Requirements

#### References:

2.5.2.2.1 WHC-SD-SNF-FRD-014, "Performance Specification for the Spent Nuclear Fuel Canister Storage Building, Rev. A, Draft" dated May 17, 1995.

2.5.2.2.2 HVAC Basis for Design for Spent Nuclear Fuel Canister Storage Building. (Appendix IV)

### 2.5.2.3 Design Criteria

2.5.2.3.1 The vault area of the CSB is a non-contaminated zone. The passive ventilation system is designed to operate with an outdoor winter design temperature of -27°F and an outdoor summer design temperature of 115°F. The maximum allowable MCO temperature is 400°F.

2.5.2.3.2 For specific Design Basis, see Appendix IV.

### 2.5.2.4 Performance Objectives

The objective of the passive ventilation system is to maintain the MCO temperature (staging/storage) below the maximum allowable limit of 400°F during normal and DBA conditions based on a maximum inlet design temperature of 115°F.

## 2.5.2.5 Design Decisions

### 2.5.2.5.1 General Design Description

While in storage, the radioactive decay heat generated by the MCOs will be removed by the passive ventilation system. The MCOs provide primary confinement and the storage tubes (along with the associated cover plug) form a secondary confinement system. The passive ventilation system provides a cooling, rather than a confinement, function. The air is drawn through the vault by natural convection due to the buoyancy forces created by the density difference between the hot air inside the vault and the cooler air outside. HEPA filtration of the passive ventilation system is not required because potential contamination from a leaking MCO will be confined to individual storage tubes and cannot enter the vault area.

The thermal feasibility analysis in Appendix IV is based on staging of drained, damp-dried MCOs in air filled tubes in vaults 1 and 2 (third vault contains no tubes and is isolated) with a passive ventilation system.

### 2.5.2.5.2 The following design basis assumptions were used for the thermal analyses:

- 2.5.2.5.2.1 The heat generation rate was based on a total 880 MCOs. Twenty percent are assumed to be at the upper limit (482 W, "maximum") and the remaining eighty percent are assumed to be at the nominal value (221 W, "average"). Due to the preliminary nature of the heat transfer calculations a ten percent safety factor was used for the heat generation rate.
- 2.5.2.5.2.2 The heat generation for the "maximum" case (482 W) per MCO was used for the calculating the MCO temperature assuming that it is located at the end of the vault. Each MCO contains ten canisters, each storage tube contains two MCOs, and each vault contains 220 tubes.
- 2.5.2.5.2.3 The maximum allowable MCO temperature during staging/storage is 400°F.
- 2.5.2.5.2.4 During the staging operation the MCO provides primary confinement and the air filled storage tubes provide the secondary confinement. It is assumed that the interior of the storage tubes are isolated from the vault, which would prevent the vault from getting contaminated.

- 2.5.2.5.2.5 The total flow is assumed to be evenly and uniformly distributed around each of the containment tubes. This is a critical assumption that must be assured by design and verified by additional analyses using Computational Fluid Dynamics (CFD) techniques.
- 2.5.2.5.2.5 The heat transfer coefficients for air were calculated at the point of maximum vault air temperature.
- 2.5.2.5.2.6 One dimensional (radial) heat transfer only. Two-dimensional (radial and axial) heat transfer was not modeled.
- 2.5.2.5.2.7 Heat transfer by radiation between the tubes was considered.
- 2.5.2.5.2.8 MCOs are inerted with nitrogen.

#### 2.5.2.6 Design Conclusions

The thermal analyses during staging/storage operation with the existing CSB design concept, assuming the same intake structure, vault size (2-vaults) and exhaust stack (height and diameter) indicates that an MCO temperature of 250°F can be maintained by a passive ventilation system. This is based on an inlet air temperature of 115°F (same design basis as CSB) and a ventilation flow rate of 53,500 CFM. The inlet supply air temperature of 115°F was selected based on the design criteria for SC-1 system. The MCO temperature is calculated on the basis that the MCO is located at the end of the vault with the limiting heat load. The vault air temperature distribution and velocity profile for a fully loaded vault with a passive ventilation system are shown on Figures 2-12 through 2-16. The maximum vault air temperature is estimated at 133°F.

The results of the thermal analysis (Appendix IV) indicate that it is feasible to maintain the MCO temperature below the maximum allowable limit of 400°F with a passive ventilation system with a supply air temperature of 115°F.

#### 2.5.1.7 Open Issues

It must be emphasized that these are rough conservative feasibility thermal analyses using limited design information and do not cover all limiting or upset conditions. More detailed analyses are required using CFD techniques to cover all limiting and upset conditions and to verify some basic assumptions. Also thermal analysis is required for MCOs stored in an overpack.

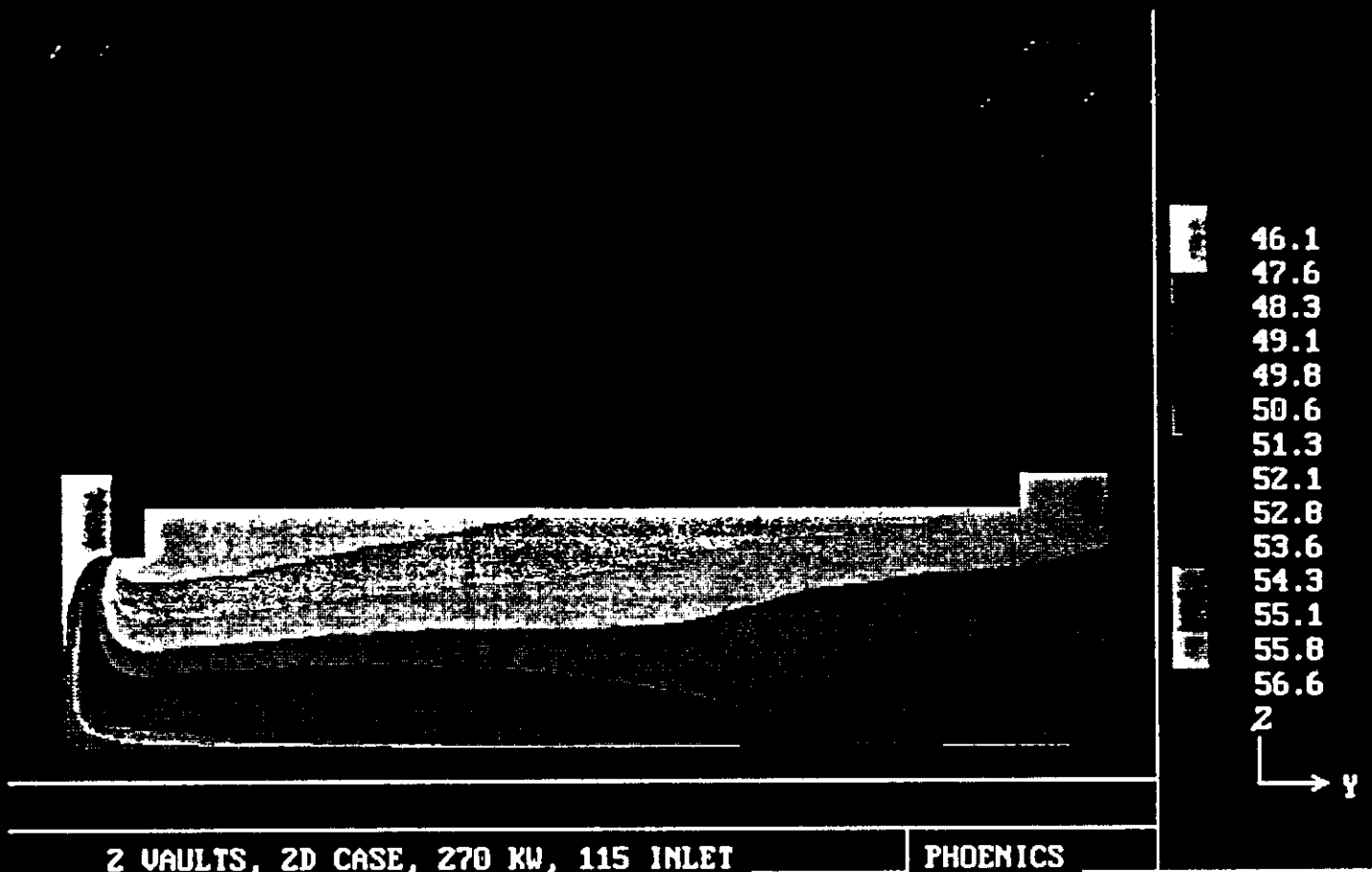


Figure 2-12  
Conceptual Design  
Passive Cooling Vault Temperature Profile

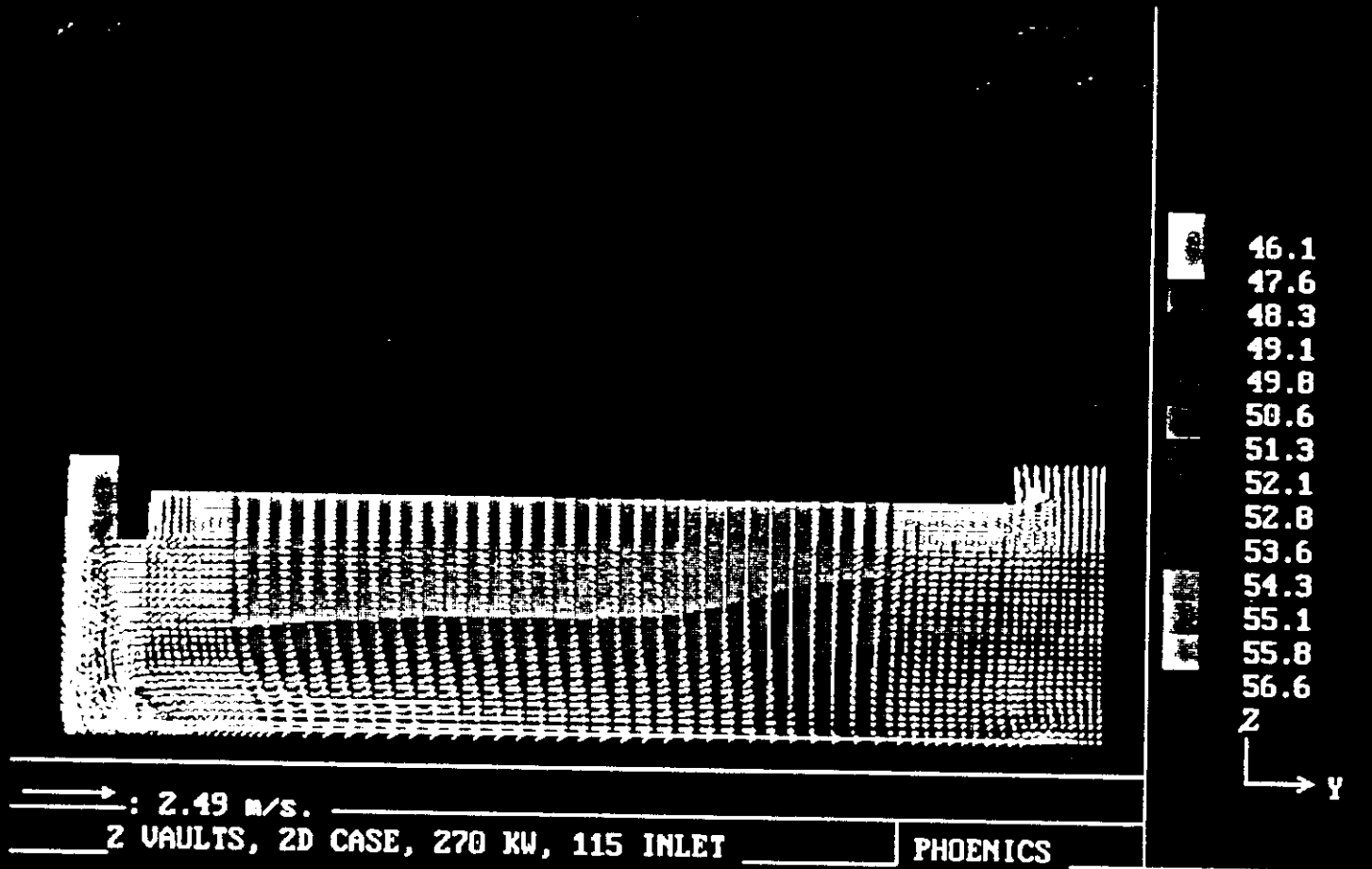


Figure 2-13  
 Conceptual Design  
 Passive Cooling Velocity Profile

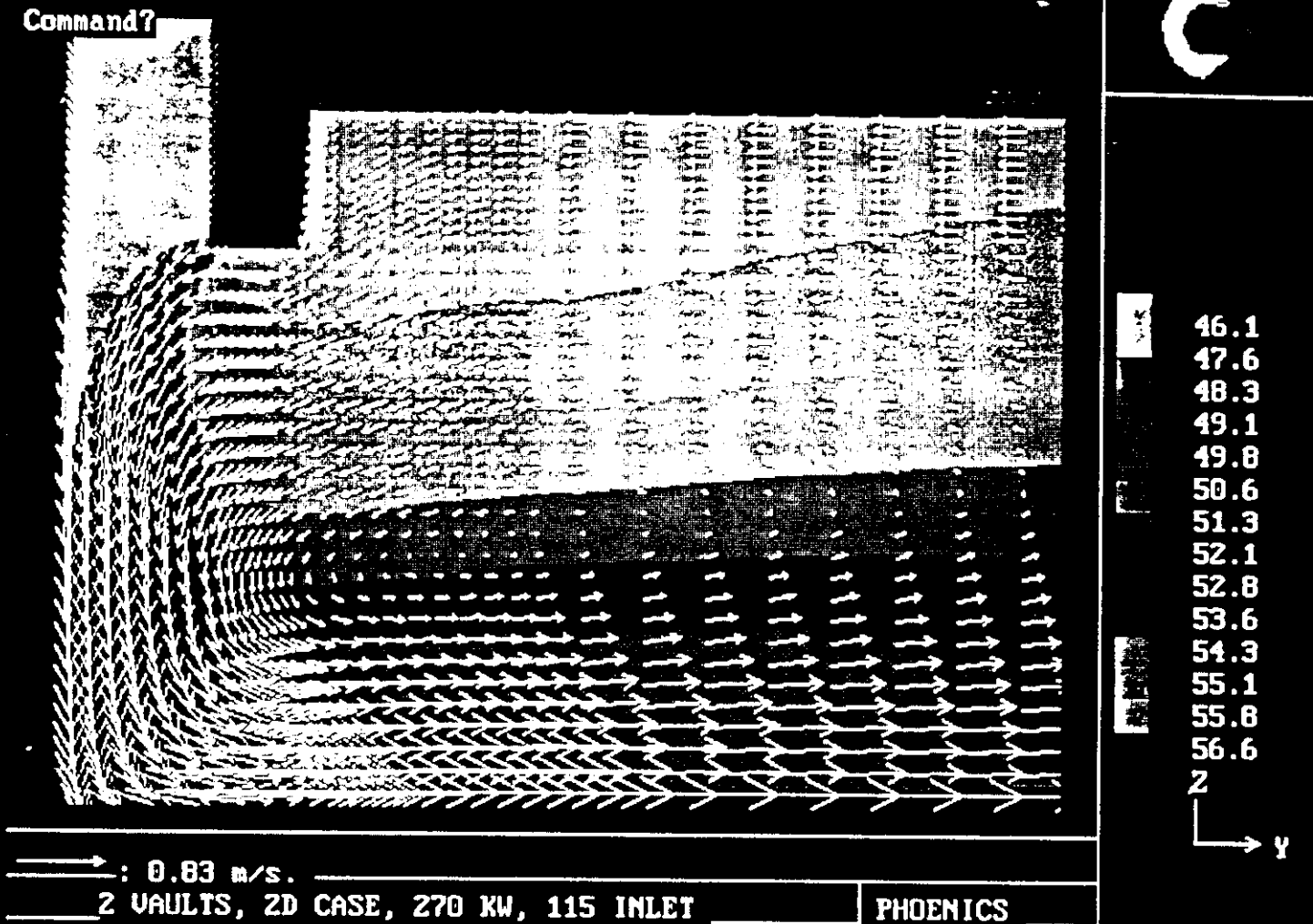


Figure 2-14

Conceptual Design  
 Passive Cooling Velocity Profile



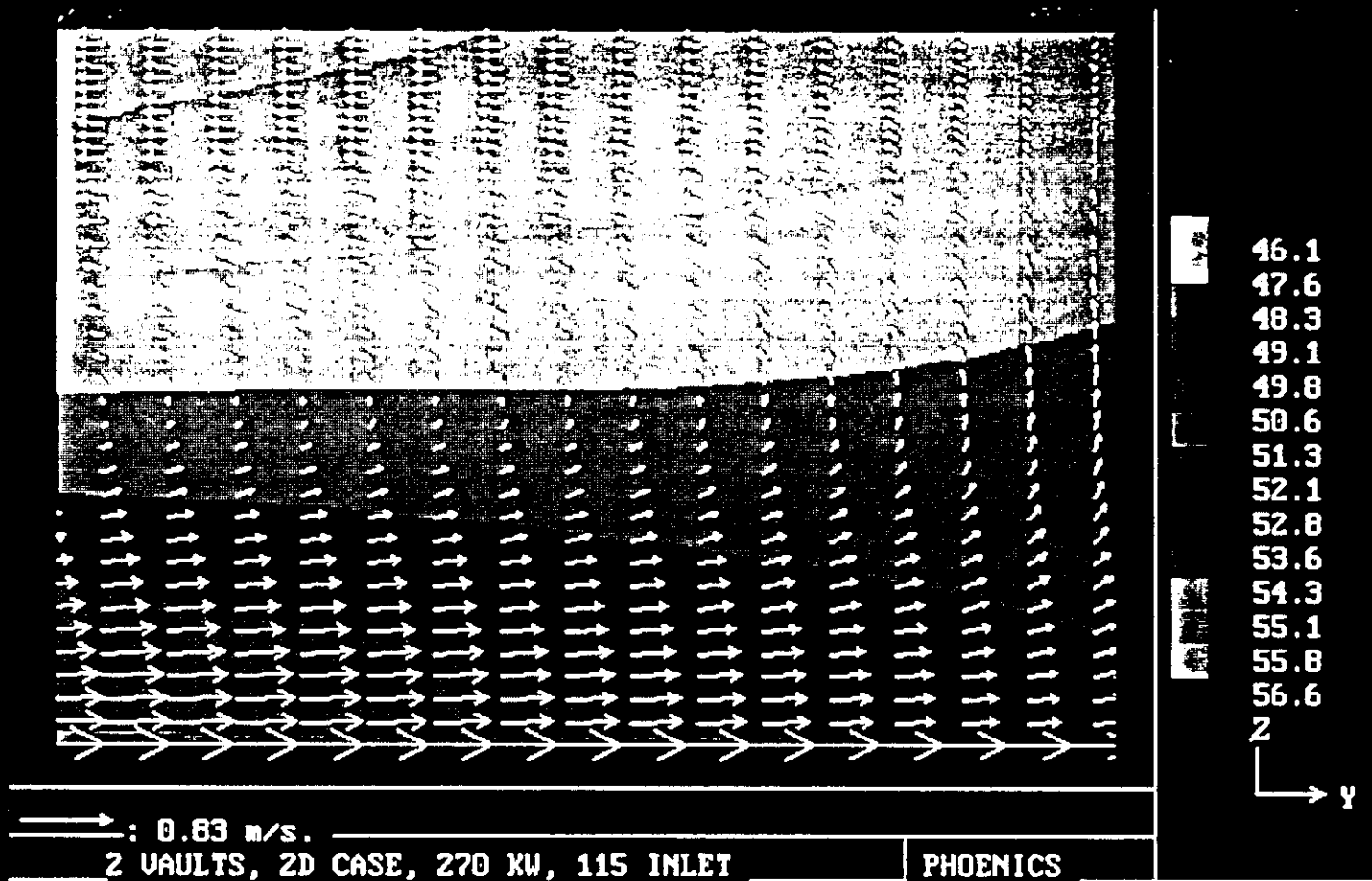


Figure 2-15

Conceptual Design  
 Passive Cooling Velocity Profile

Command?

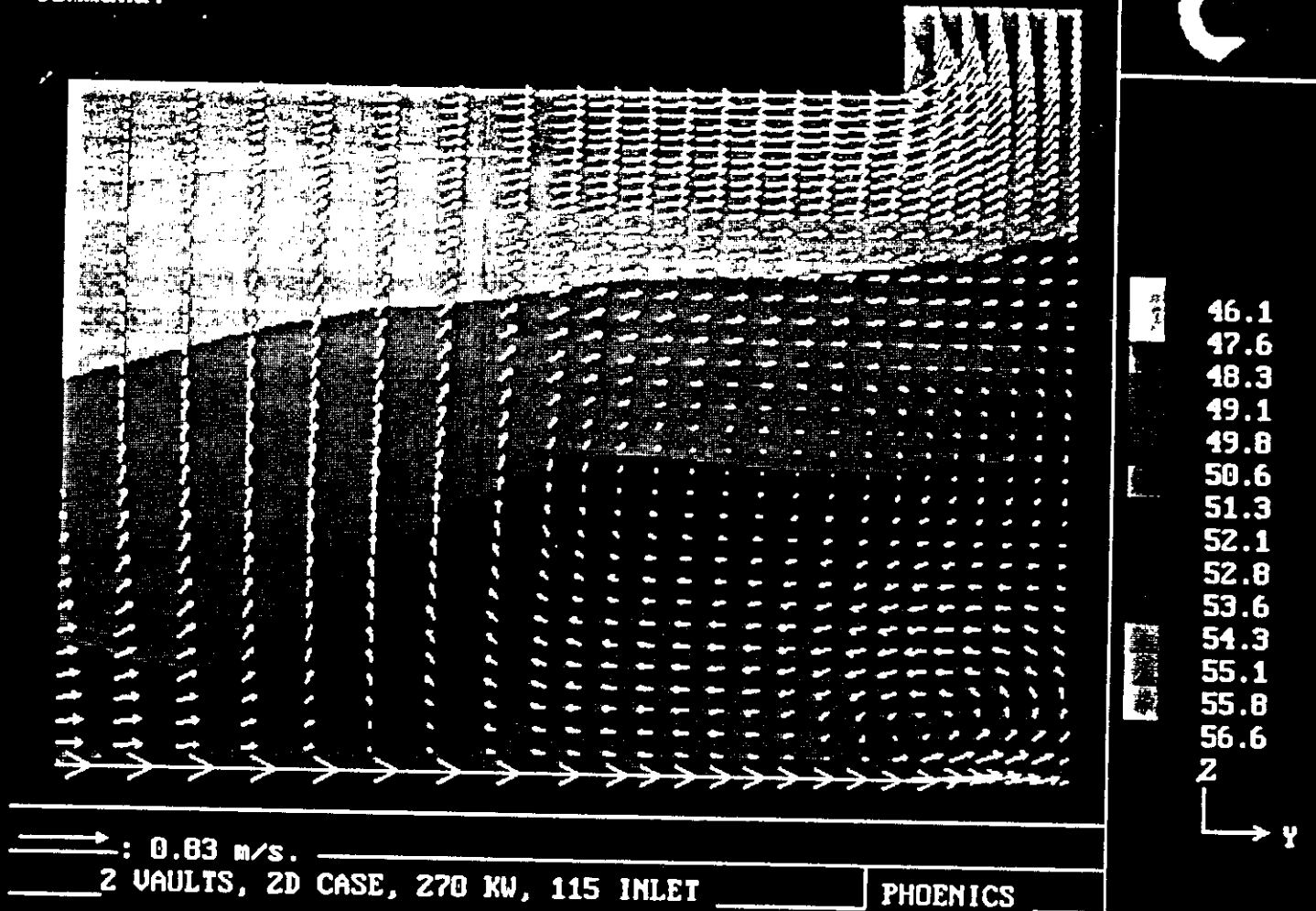


Figure 2-16  
 Conceptual Design  
 Passive Cooling Velocity Profile

### 2.5.3 Operating Area HVAC System

#### 2.5.3.1 System Description

The Operating Area HVAC System provides heating and cooling of this area. This system is also capable of diluting the hydrogen and krypton-85 to acceptable levels by introducing sufficient amounts of outside air. This system is not designed to operate during and after a DBA.

The block flow diagram for the HVAC system serving this area is shown on Figure 2-17. Two 50 percent capacity Air Handling Units (AHU-1 & 2), supply conditioned air to the Operating and Cask Loading Areas during summer to maintain the design temperature and provide sufficient amount of outside air to dilute the hydrogen and krypton-85 concentrations below acceptable levels. During winter the Air Handling Units (AHU-1 & 2) are shut down and the Air Handling Unit (AHU-3) is activated to maintain the winter design temperatures in these areas and also provide adequate quantity of outside air to dilute hydrogen and krypton-85.

#### 2.5.3.2 Originating Requirements

##### References:

2.5.3.2.1 WHC-SD-SNF-FRD-014, "Performance Specification for the Spent Nuclear Fuel Canister Storage Building, Rev. A, Draft dated May 17, 1995.

2.5.3.2.2 HVAC Basis for Design for Spent Nuclear Fuel Canister Storage Building. (Appendix IV)

#### 2.5.3.3 Design Criteria

2.5.3.3.1 The Operating and Cask Loading Areas will be maintained during summer at a maximum temperature of 85°F and at a minimum winter temperature of 55°F. No temperature control is provided for these areas following a DBA.

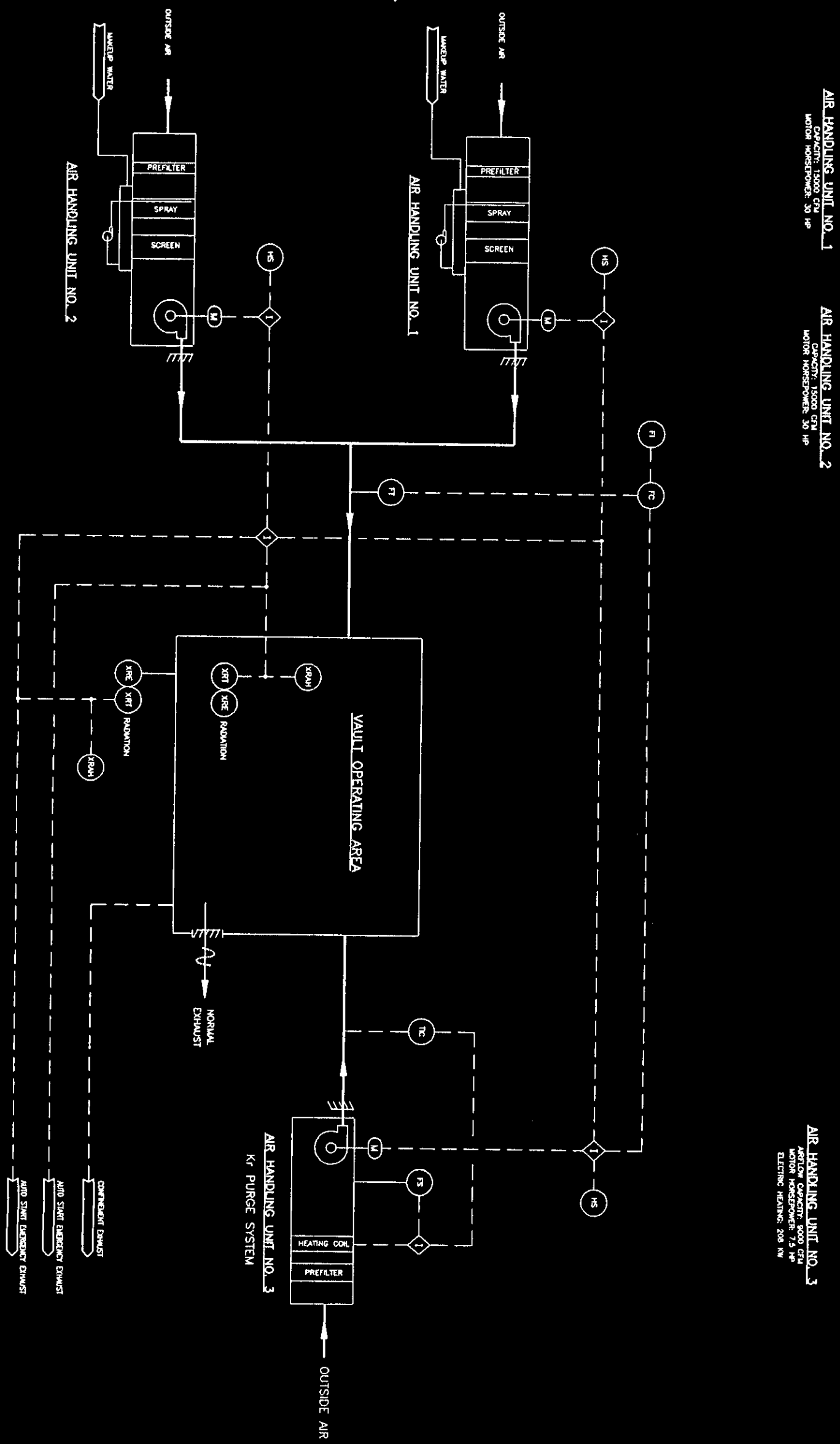
2.5.3.3.2 For specific Design Basis, see Appendix IV.

#### 2.5.3.4 Performance Objectives

The objective of the Operating and Cask Loading Areas HVAC system is to provide adequate ventilation for purging of the hydrogen and krypton-85 and to maintain the design temperatures in these areas.

#### 2.5.3.5 Design Decisions

The Operating area is normally a non-contaminated area. In case of an accident (potential drop of an MCO and release of contamination



SNF CSB  
CONCEPTUAL DESIGN  
VAULT OPERATING AREA  
HVAC FLOW DIAGRAMS  
FIGURE 2-17

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to the operating area) a Safety Class 2 emergency ventilation system (Figure 2-18) is activated to maintain confinement of the Operating Area. This emergency ventilation system is interlocked to stop the normal HVAC system (AHU-1&2 or AHU-3), serving this area.

## 2.5.4 Operating Area Emergency HVAC System

### 2.5.4.1 System Description

The Operating Area Emergency HVAC System provides confinement for this area after an accident (potential drop of an MCO and release of contamination to the operating area). The block flow diagram for this system is shown on Figure 2-18. This system is Safety Class 2 and consists of two redundant systems with HEPA filtration (FP-1A and 1B) and exhaust fans (EF-1A & 1B). Failure of the exhaust ventilation system automatically starts the standby system. The air from this system is exhausted to the atmosphere through an exhaust stack.

### 2.5.4.2 Originating Requirements

#### References:

2.5.4.2.1 WHC-SD-SNF-FRD-014, "Performance Specification for the Spent Nuclear Fuel Canister Storage Building, Rev. A, Draft dated May 17, 1995.

2.5.4.2.2 HVAC Basis for Design for Spent Nuclear Fuel Canister Storage Building. (Appendix IV)

### 2.5.4.3 Design Criteria

2.5.4.3.1 The Operating Area is classified as Ventilation Zone IIIA and will be maintained at 0.1 inch. W.G. negative pressure with respect to the atmosphere during the operation of the emergency HVAC system. No temperature control is provided for this area following a DBA.

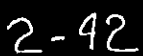
2.5.4.3.2 For specific Design Basis, see Appendix IV.

### 2.5.4.4 Performance Objectives

The objective of the Operating Area Emergency HVAC system is to maintain confinement in the Operating Area after a DBA.

### 2.5.4.5 Design Decisions

The Operating area is normally a non-contaminated area. In case of an accident (potential drop of an MCO and release of contamination to the operating area) this Emergency HVAC System (Safety Class 2),



is activated to maintain confinement. This system is interlocked to stop the HVAC system (Figure 2-18; AHU-1&2 or AHU-3) which serves these areas during normal operation.

## 2.5.5 MCO/Cask Transfer Tunnel Area HVAC System

### 2.5.5.1 System Description

The MCO/Cask Transfer Tunnel Area HVAC System provides confinement for the MCO/Cask Transfer Tunnel Area, Radioactive Maintenance Area and the Waste Handling Area during normal and SC-2 DBA conditions. The block flow diagram for this system is shown on Figure 2-19. This exhaust system is Safety Class 2 and consists of two redundant systems with HEPA filtration (FP-3A & 3B) and exhaust fans (EF-3A & 3B). The supply air to these areas is from the Load-In/Load-Out area HVAC system. The air from this system is exhausted to the atmosphere through an exhaust stack.

### 2.5.5.2 Originating Requirements

#### References:

2.5.5.2.1 WHC-SD-SNF-FRD-014, "Performance Specification for the Spent Nuclear Fuel Canister Storage Building, Rev. A, Draft dated May 17, 1995.

2.5.5.2.2 HVAC Basis for Design for Spent Nuclear Fuel Canister Storage Building. (Appendix IV).

### 2.5.5.3 Design Criteria

2.5.5.3.1 The MCO/Cask Transfer Tunnel Area, Radioactive Maintenance Area and the Waste Handling Area are classified as Ventilation Zone II and will be maintained at 0.5 inch W.G. negative pressure with respect to the atmosphere during normal and abnormal conditions. No temperature control is provided for these areas following a SC-2 DBA.

2.5.5.3.2 For specific Design Basis, see Appendix IV.

### 2.5.5.4 Performance Objectives

The objective of the MCO/Cask Transfer Tunnel Area HVAC system is to maintain confinement in these areas during normal and SC-2 DBA.

### 2.5.5.5 Design Decisions

There are no unusual conditions or assumptions upon which the design is based.





## 2.5.6 Load-In/Load-Out Area HVAC System

### 2.5.6.1 System Description

The Load-In/Load-Out area HVAC System provides confinement and maintains the design temperatures for the Load-In/Load-Out area and the miscellaneous support areas. The block flow diagram for this system is shown on Figure 2-20. The system consists of two 100 percent capacity air handling units (AHU-4A and 4B) which supply conditioned air to these areas. The air from these areas is recirculated/exhausted by two 100 percent capacity return/exhaust fans (EF-2A and 2B) through two 100 percent HEPA filter plenums (FP-2A and 2B). Failure of one operating HVAC system automatically starts the standby system. In the event of an accident in the Load-In/Load-Out area the return air dampers close and the system exhausts 100 percent to the outside. The air from this system is exhausted to the atmosphere through an exhaust stack.

### 2.5.6.2 Originating Requirements

#### References:

2.5.6.2.1 WHC-SD-SNF-FRD-014, "Performance Specification for the Spent Nuclear Fuel Canister Storage Building, Rev. A, Draft dated May 17, 1995.

2.5.6.2.2 HVAC Basis for Design for Spent Nuclear Fuel Canister Storage Building. (Appendix IV).

### 2.5.6.3 Design Criteria

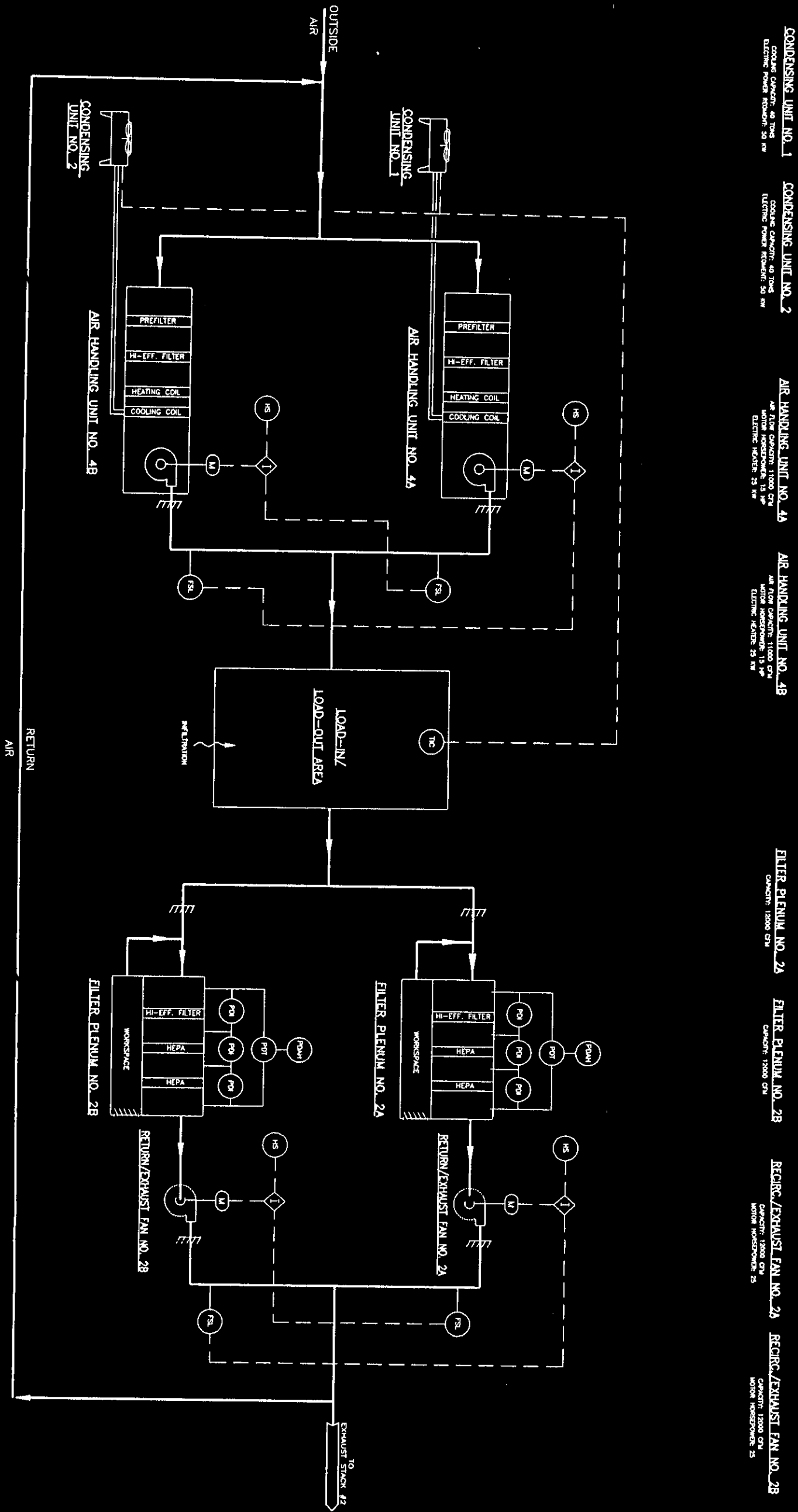
The Load-In/Load-Out area is classified as a Ventilation Zone IIIA and will be maintained at a 0.1 inch W.G. negative pressure with respect to the atmosphere during normal operations. This system is not designed for SC-2 DBA operation.

### 2.5.6.4 Performance Objectives

The objective of the Load-In/Load-Out area HVAC system is to maintain confinement and design temperatures in these areas during normal operations and from a potential release of radioactivity from a MCO/Transportation Cask Accident in the Load-In/Load-Out area.

### 2.5.6.5 Design Decisions

There are no unusual conditions or assumptions upon which the design is based.



SNF CSB

CONCEPTUAL DESIGN

LOAD-IN/LOAD-OUT AREA

HVAC FLOW DIAGRAM

FIGURE 2-20

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## 2.6 ELECTRICAL ENGINEERING

### 2.6.1 Introductory/Summary

The electrical distribution system for the SNF CSB will be fed directly from the existing 13.8 kV poleline located at the site via a 750 kVA outdoor pad-mounted utility transformer. The facility loads will be radially fed from a service entrance 480 volt switchgear. The switch gear will be double ended with a normally closed tie breaker, and will have provisions for connecting a portable generator in case of utility failure or maintenance requirement. In addition to the normal facility loads, the switchgear will feed two trains of emergency, Safety Class 2, MCCs via automatic transfer switches. The SC2 electrical equipment and associated generators supply power to the SC2 HVAC equipment during a loss of utility power or upon detection of radiation in the operating area. The facility will be provided with normal and emergency communication systems, alarms and a public address system. Essential loads such as the HPS and DCS will be provided with uninterruptable power.

### 2.6.2 Criteria

The fundamental criteria for the electrical design is that it meets the performance specification, matches the capability of the electrical system that energizes it, meets all regulatory requirements, matches the building characteristics, uses quality materials, can be maintained without interrupting service, can be operated with a small chance of error resulting in interruption of service and is safe, reliable and cost effective.

2.6.2.1 The major codes that the design must comply with are

- DOE Order 6430.1A
- NFPA 70, National Electrical Code (NEC)
- ANSI C2, National Electrical Safety Code (NESC)
- NFPA 101, Life Safety Code
- WHC-CM-1-3 (MRP 5.46) & Supporting Document WHC-SD-GN-303, "Backup Electrical Power System Definitions and Design Criteria"
- Illumination Engineering Society (IES) Handbook

2.6.2.2 IEEE standards for power distribution (red book), grounding (green book), protection (buff book), backup power (orange book) will be used as guidelines. Additionally, the IEEE 1E guidelines for independence and singlepoint failure will be used for the design of the SC2 electrical system.

2.6.2.3 There are several other codes and standards that apply and are for the most part referenced in the major codes identified above.

2.6.2.4 All equipment shall be UL approved or recognized as part of an assembly. Third party testing and certification of equipment by a nationally recognized testing laboratory is acceptable for equipment that is not UL recognized.

### 2.6.3 Design Approach for Conceptual Design

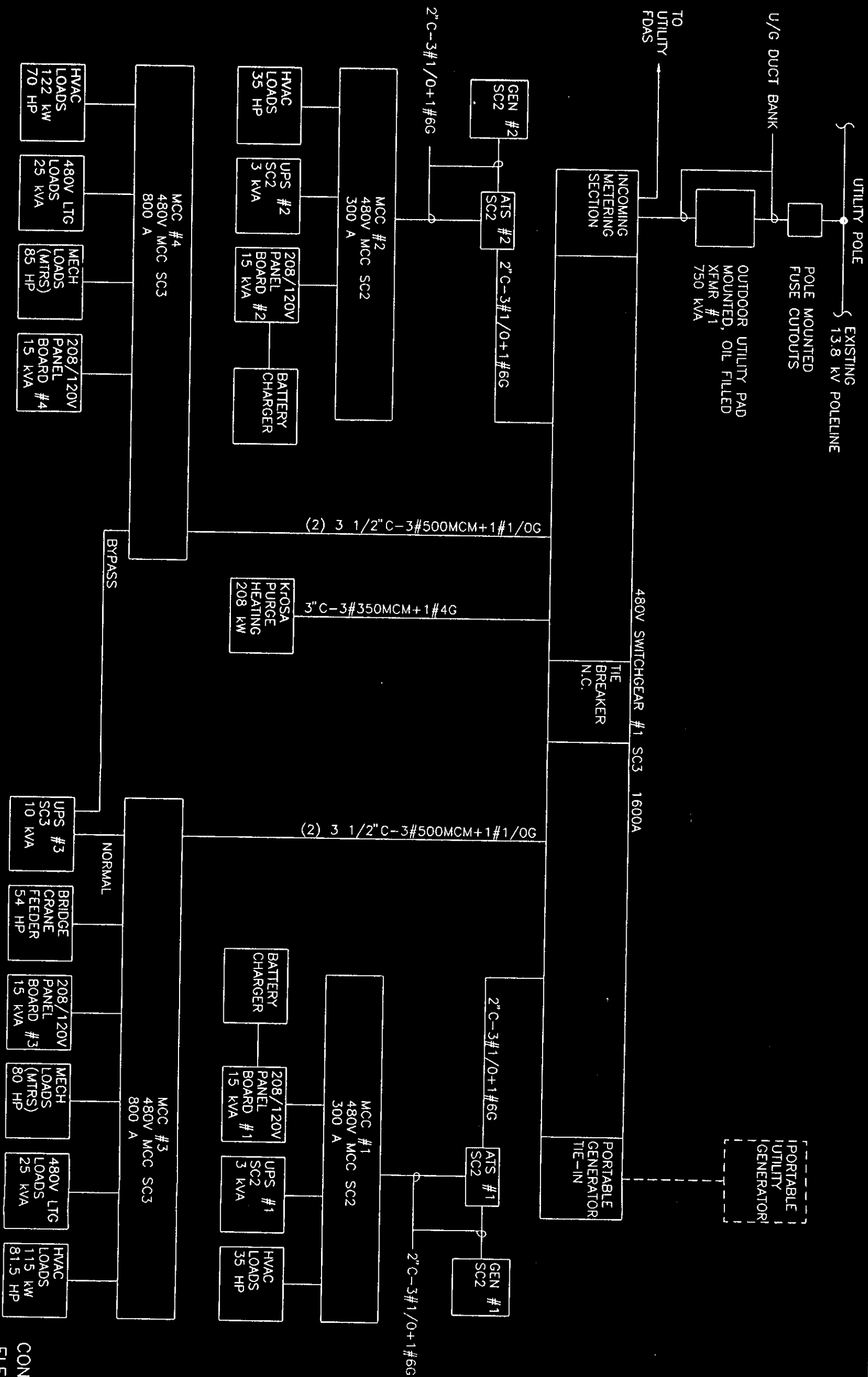
The general design approach and sequence was to gather data on the existing design and the Canister Storage Building Trade Study Concept "2D" and to obtain information on HVAC, process and mechanical loads for calculating the facility load requirements for the utility service and system configuration. The safety analysis was also reviewed to determine the safety class electrical requirements. Once the facility loads were established and the safety class requirements identified, the electrical system was configured (one line diagram) to meet those requirements in a block diagram form Figure 2-21. The service drop requirements and any special utility requirements that may apply were established with the site Electric Utilities (EU) group.

The facility loads were depicted on the one line diagram as block loads for mechanical, HVAC, process and electrical lighting and general purpose loads. The loads were then further broken down in to load schedules Tables 2-2 through 2-6 for each major piece of electrical equipment (i.e. switchgear, MCCs, etc.). The load schedules were used to determine starter sizes, bus sizes and equipment capacities for sizing equipment and obtaining cost data. The equipment sizes were used to configure the electrical rooms and size the backup generators for the Safety Class 2 loads.

### 2.6.4 Electrical System Configuration

#### 2.6.4.1 Safety Class Effects on System Configuration

The primary driver for the electrical system configuration is the safety classification. Per the Canister Storage Building Trade Study Concept 2D, there is a requirement for a Safety Class 2 electrical system to support the SC2 HVAC system required to provide confinement in the operating area upon detection of radiation. The safety analysis indicates that a failed MCO due to a drop from a significant height (crane) is a credible scenario that could result in a SC2 release of radioactivity. However, DOE 6430.1A Section 1300-3.2, implies that Safety Class 2 is a nonsafety class system. Therefore, WHC criteria WHC-CM-1-3 (MRP 5.46) is used for the design of the Safety Class 2 backup power system. In general, the Safety Class 2 electrical system design is similar to a class 1E system as far as redundancy and single point



SNF CSB  
CONCEPTUAL DESIGN  
ELECTRICAL SYSTEM  
ONE LINE DIAGRAM  
FIGURE 2-21

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Table 2-2

# MCC/SWGR LOADS

MCC # 1 SC2

|   | Equip. No.   | Description            | HP              | kVA | kW  | NEC FLA | Cond. Size | Starter Size | Space      |
|---|--------------|------------------------|-----------------|-----|-----|---------|------------|--------------|------------|
| 1 | EF-1         | Emergency Exh. Fan "A" | 15              |     |     | 21      | 3#10+1#10G | 2            | 1 cubicle  |
| 2 | EF-1         | Exhaust Fan            | 10              |     |     | 14      | 3#12+1#12G | 1            | 1 cubicle  |
| 3 | SF-1         | Supply Fan "A"         | 10              |     |     | 14      | 3#12+1#12G | 1            | 1 cubicle  |
| 4 | UPS #1       |                        |                 | 3   |     | 3.6     | 3#12+1#12G |              | .5 cubicle |
| 5 | Panel Brd #1 | 208/120V Panel Board   |                 | 15  |     | 18      | 3#10+1#10G |              | .5 cubicle |
| 6 |              | Spare                  |                 |     |     |         |            | 1            | 1 cubicle  |
|   |              |                        | Total Connected |     | 71A |         |            |              |            |

## Generator Sizing:

|                           |                |
|---------------------------|----------------|
| Subtotal kVA              | 53 kVA         |
| Gen. Spare Capacity (25%) | 13 kVA         |
| Additional Motor Starting | <u>125 kVA</u> |
| Total kVA Required        | 191 kVA        |

|                |       |
|----------------|-------|
| Generator Size | 80 kW |
|----------------|-------|

Table 2-3

**MCC/SWGR LOADS**

MCC # 2 SC2

|                 | Equip.<br>No.   | Description               | HP | kVA | kW | NEC<br>FLA | Cond. Size | Starter<br>Size | Space      |
|-----------------|-----------------|---------------------------|----|-----|----|------------|------------|-----------------|------------|
| 1               | EF-2            | Emergency<br>Exh. Fan "B" | 15 |     |    | 21         | 3#10+1#10G | 2               | 1 cubicle  |
| 2               | EF-2            | Exhaust Fan               | 10 |     |    | 14         | 3#12+1#12G | 1               | 1 cubicle  |
| 3               | SF-2            | Supply Fan<br>"B"         | 10 |     |    | 14         | 3#12+1#12G | 1               | 1 cubicle  |
| 4               | UPS #2          |                           |    | 3   |    | 3.6        | 3#12+1#12G |                 | .5 cubicle |
| 5               | Panel<br>Brd #2 | 208/120V<br>Panel Board   |    | 15  |    | 18         | 3#10+1#10G |                 | .5 cubicle |
| 6               |                 | Spare                     |    |     |    |            |            | 1               | 1 cubicle  |
| Total Connected |                 |                           |    |     |    | 71A        |            |                 |            |

Generator Sizing:

|                           |                |
|---------------------------|----------------|
| Subtotal kVA              | 53 kVA         |
| Gen. Spare Capacity (25%) | 13 kVA         |
| Additional Motor Starting | <u>125 kVA</u> |
| Total kVA Required        | 191 kVA        |

|                |       |
|----------------|-------|
| Generator Size | 80 kW |
|----------------|-------|

Table 2-4  
Sheet 1 of 2

# MCC/SWGR LOADS

MCC # 3 SC2

|    | Equip. No. | Description                  | HP  | kVA | kW | NEC FLA | Cond. Size | Starter Size | Space       |
|----|------------|------------------------------|-----|-----|----|---------|------------|--------------|-------------|
| 1  | AHU-1      | Air Washer                   | 30  |     |    | 40      | 3#8+1#10G  | 3            | 1.5 cubicle |
| 2  | AHU-3      | Kr OSA Purge                 | 7.5 |     |    | 11      | 3#12+1#12G | 1            | 1 cubicle   |
| 3  | AHU-1      | Air Handling Unit Dx Cooling | 15  |     |    | 21      | 3#10+1#10G | 2            | 1 cubicle   |
| 4  |            | Heating                      |     |     | 25 | 30      | 3#8+1#10G  |              | .5 cubicle  |
| 5  | ACC-1      | Air Cooled Condensing Unit   |     |     | 50 | 60      | 3#4+1#8G   |              | .5 cubicle  |
| 6  | EF-1       | Recirc/Exh. Fan              | 25  |     |    | 34      | 3#8+1#10G  | 2            | 1 cubicle   |
| 7  | EH-1       | Electric Unit Heaters        |     |     | 10 | 12      | 3#12+1#12G |              | .5 cubicle  |
| 8  | EH-3       | Electric Unit Heaters        |     |     | 10 | 12      | 3#12+1#12G |              | .5 cubicle  |
| 9  | AHU-1      | Air Handling Unit            | 3   |     |    | 4.8     | 3#12+1+12G | 1            | 1 cubicle   |
| 10 | EF-1       | Exhaust Fan                  | 1   |     |    | 1.8     | 3#12+1+12G | 1            | 1 cubicle   |
| 11 | EH-1       | Electric Unit Heaters        |     |     | 10 | 12      | 3#12+1+12G |              | .5 cubicle  |
| 12 | EH-3       | Electric Unit Heaters        |     |     | 10 | 12      | 3#12+1+12G |              | .5 cubicle  |
| 13 | C-1A       | Air Compressor               | 40  |     |    | 52      | 3#4+1#8G   | 3            | 1.5 cubicle |
| 14 | MB-1A      | HPS Vac. Sys. Blower         | 30  |     |    | 40      | 3#8+1#10G  | 3            | 1.5 cubicle |
| 15 | CN-1       | Bridge Crane (40 Ton)        | 15  |     |    | 21      | 3#6+1#10G  |              | .5 cubicle  |
| 16 |            |                              | 5   |     |    | 7.6     |            |              |             |
| 17 |            |                              | 5   |     |    | 7.6     |            |              |             |
| 18 |            |                              | 2   |     |    | 3.4     |            |              |             |
| 19 | CN-2       | Jib Crane (5 Ton)            | 2   |     |    | 3.4     | 3#12+1#12G | 1            | 1 cubicle   |
| 20 | CN-3       | Jib Crane (10 Ton)           | 2   |     |    | 3.4     | 3#12+1#12G | 1            | 1 cubicle   |
| 21 |            | Jib Crane (10 Ton)           | 1   |     |    | 1.8     | 3#12+1#12G | 1            | 1 cubicle   |



Table 2-4  
 Sheet 2 of 2

# MCC/SWGR LOADS

MCC # 3 SC2

|                 | Equip.<br>No.   | Description                   | HP | kVA | kW | NEC<br>FLA | Cond. Size | Starter<br>Size | -Space      |
|-----------------|-----------------|-------------------------------|----|-----|----|------------|------------|-----------------|-------------|
| 22              | CN-4            | Bridge Crane<br>(110 Ton)     | 15 |     |    | 21         | 3#6+1#10G  |                 | .5 cubicle  |
| 23              |                 |                               | 5  |     |    | 7.6        |            |                 |             |
| 24              |                 |                               | 5  |     |    | 7.6        |            |                 |             |
| 25              |                 |                               | 2  |     |    | 3.4        |            |                 |             |
| 26              | CN-5A           | Cask<br>Transfer<br>Cart      | 2  |     |    | 3.4        | 3#12+1#12G | 1               | 1 cubicle   |
| 27              | CN-6            | Mono Rail<br>(10 Ton)         | 2  |     |    | 3.4        | 3#12+1#12G | 1               | 1 cubicle   |
| 28              |                 |                               | 1  |     |    | 1.8        | 3#12+1#12G | 1               | 1 cubicle   |
| 29              | UPS #3          |                               |    | 10  |    | 12         | 3#12+1#12G |                 | .5 cubicle  |
| 30              | Panel<br>Brd #3 | 208/120V<br>Panel Board       |    | 15  |    | 18         | 3#10+1#10G |                 | .5 cubicle  |
| 31              |                 | 480V<br>Lighting              |    | 25  |    | 30         | 3#8+1#10G  |                 | 2 cubicle   |
| 32              |                 | Spare                         |    |     |    |            |            | 3               | 1.5 cubicle |
| 33              |                 | Spare                         |    |     |    |            |            | 2               | 1 cubicle   |
| 34              | P-8A            | DRX Line<br>Discharge<br>Pump | 5  |     |    | 7.6        | 3#12+1#12G | 1               | 1 cubicle   |
| 35              |                 | Spare                         |    |     |    |            |            | 1               | 1 cubicle   |
| Total Connected |                 |                               |    |     |    | 507A       |            |                 |             |

Table 2-5  
Sheet 1 of 2

# MCC/SWGR LOADS

MCC # 4 SC3

|    | Equip. No. | Description                  | HP | kVA | kW | NEC FLA | Cond. Size | Starter Size | Space       |
|----|------------|------------------------------|----|-----|----|---------|------------|--------------|-------------|
| 1  | AHU-2      | Air Washer                   | 30 |     |    | 40      | 3#8+1#10G  | 3            | 1.5 cubicle |
| 2  | AHU-2      | Air Handling Unit Dx Cooling | 15 |     |    | 21      | 3#10+1#10G | 2            | 1 cubicle   |
| 3  |            | Heating                      |    |     | 25 | 30      | 3#8+1#10G  |              | .5 cubicle  |
| 4  | ACC-2      | Air Cooled Condensing Unit   |    |     | 50 | 60      | 3#4+1#8G   |              | .5 cubicle  |
| 5  | EF-2       | Recirc/Exh. Fan              | 25 |     |    | 34      | 3#8+1#10G  | 2            | 1 cubicle   |
| 6  | EH-2       | Electric Unit Heaters        |    |     | 10 | 12      | 3#12+1#12G |              | .5 cubicle  |
| 7  | EH-4       | Electric Unit Heaters        |    |     | 10 | 12      | 3#12+1#12G |              | .5 cubicle  |
| 8  | ACC-1      | Air Cooled Condensing Unit   |    |     | 7  | 8.5     | 3#12+1#12G |              | .5 cubicle  |
| 9  | EH-2       | Electric Unit Heaters        |    |     | 10 | 12      | 3#12+1#12G |              | .5 cubicle  |
| 10 | EH-4       | Electric Unit Heaters        |    |     | 10 | 12      | 3#12+1#12G |              | .5 cubicle  |
| 11 | C-1B       | Air Compressor               | 40 |     |    | 52      | 3#4+1#8G   | 3            | 1.5 cubicle |
| 12 | MB-1B      | HPS Vac. Sys. Blower         | 30 |     |    | 40      | 3#8+1#10G  | 3            | 1.5 cubicle |
| 13 | CN-5B      | Cask Transfer Cart           | 2  |     |    | 3.4     | 3#12+1#12G | 1            | 1 cubicle   |
| 14 | CK-1       | Facility Bottom Loading Cask | 2  |     |    | 3.4     | 3#12+1#12G | 1            | 1 cubicle   |
| 15 |            |                              | 1  |     |    | 1.8     | 3#12+1#12G | 1            | 1 cubicle   |
| 16 | CK-2       | Floor Plug Flask             | 1  |     |    | 1.8     | 3#12+1#12G | 1            | 1 cubicle   |
| 17 | GA-1       | Portable Shielding Gate      | 1  |     |    | 1.8     | 3#12+1#12G | 1            | 1 cubicle   |
| 18 | GA-2       | Fixed Shielding Gate         | 1  |     |    | 1.8     | 3#12+1#12G | 1            | 1 cubicle   |
| 19 | SS-1       | MCO Service Station          | 1  |     |    | 1.8     | 3#12+1#12G | 1            | 1 cubicle   |
| 20 |            |                              | 1  |     |    | 1.8     | 3#12+1#12G | 1            | 1 cubicle   |
| 21 | RA-4       | Cask Entrance Hatch          | 2  |     |    | 3.4     | 3#12+1#12G | 1            | 1 cubicle   |

Table 2-5  
 Sheet 2 of 2

## MCC/SWGR LOADS

MCC # 4 SC3

|    | Equip.<br>No.   | Description                     | HP | kVA   | kW | NEC<br>FLA | Cond. Size | Starter<br>Size | -Space      |
|----|-----------------|---------------------------------|----|-------|----|------------|------------|-----------------|-------------|
| 22 | CN-7            | MCO Transfer<br>Cart            | 1  |       |    | 1.8        | 3#12+1#12G | 1               | 1 cubicle   |
| 23 | HD-2            | Bolting/<br>Unbolting<br>Device | 1  |       |    | 1.8        | 3#12+1#12G | 1               | 1 cubicle   |
| 24 |                 |                                 | 1  |       |    | 1.8        | 3#12+1#12G | 1               | 1 cubicle   |
| 25 | Panel<br>Brd #4 | 208/120V<br>Panel Board         |    | 15    |    | 18         | 3#10+1#10G |                 | .5 cubicle  |
| 26 |                 | 480V<br>Lighting                |    | 25    |    | 30         | 3#8+1#10G  |                 | 2 cubicle   |
| 27 |                 | Spare                           |    |       |    |            |            | 3               | 1.5 cubicle |
| 28 |                 | Spare                           |    |       |    |            |            | 2               | 1 cubicle   |
| 29 | P-8B            | DRX Line<br>Discharge<br>Pump   | 5  |       |    | 7.6        | 3#12+1#12G | 1               | 1 cubicle   |
| 30 |                 | Spare                           |    |       |    |            |            | 1               | 1 cubicle   |
|    |                 | Total Connected                 |    | 415 A |    |            |            |                 |             |

Table 2-6

## MCC/SWGR LOADS

SWGR # 1 Demand Load

|              | Equip. No. | Description    | FLA | Feeder Size  |
|--------------|------------|----------------|-----|--------------|
| 1            | MCC #1     | SC2 MCC        | 22  | 3#1/0+1#6G   |
| 2            | MCC #2     | SC2 MCC        | 36  | 3#1/0+1#6G   |
| 3            | MCC #3     | SC3 MCC        | 272 | 3#500+1#1/0G |
| 4            | MCC #4     | SC3 MCC        | 315 | 3#500+1#1/0G |
| 5            |            | Kr OSA Heating | 200 | 3#350+1#4G   |
| 6            |            |                |     |              |
| Total Demand |            |                | 845 | A            |

### Assumptions For Summer Time Peak Demand Calculations:

1. Emergency /Spare/Stand-by loads are not included.
2. If a load has an "A" & a "B", "B" is considered a stand-by.
3. Compressor load is not included (winter only).
4. Only one crane is operating at a given time.

failure with the exception of the equipment quality requirements (commercial grade is acceptable) and the utility service. Per 6430.1A Section 1630-1.3, a redundant, dedicated utility supply is required to supply class 1E systems if the facility is deemed "critical " by the DOE.

#### 2.6.4.2 Physical Configuration

A single utility service drop from the existing 13.8 kV poleline located near the site will be utilized and fed underground via concrete ductbank to an outdoor pad-mounted oil filled 13.8-0.48/.27 kV transformer. The pole will be retrofitted with fuse cutouts for the service drop. Pole mounted gang operated switches are not acceptable to the EU. The transformer will be provided with bayonet fuses and a loop feed. Additionally, as part of the next phase of design, flapper valves manufactured by Cooper Power Systems will be investigated for incorporation into the transformer design per WHC EU request. The transformer will have a radial feed to an indoor double-ended 480 volt switchgear with a normally-closed tie breaker. One side of the switchgear will be connected to the incoming utility line and the other side will have provisions for connecting a portable utility generator in case of a power outage or for purposes of maintenance. Each side of the main switchgear will feed an MCC train. Two trains of MCC's are provided in support of the HVAC and mechanical equipment trains. The dual equipment trains are provided for purposes of maintainability and availability. Similarly, each switchgear bus will feed the Safety Class 2 MCCs.

The Safety Class 2 electrical equipment is contained in separate and independent electrical rooms. The SC2 backup generators are connected to the SC2 MCC's via automatic transfer switches.

The equipment sizes are calculated taking into consideration the seasonal demand and diversity factors per the 6430.1A Section 1630-1.1 requirements. Energy conservation requirements are met by providing a kWhr demand meter that also ties into the utility FDAS and by utilizing energy efficient equipment such as High Intensity Discharge (HID) lighting wherever possible. Due to the type of operation, automatic timers for lighting control will not be utilized. Therefore, energy conservation with respect to the lighting controls will be administrative.

#### 2.6.5 Electrical System Requirements

To facilitate definitive design, references are made to design standards and details contained in HWVP design packages that can be used for the CSB design (e.g. lighting details, grounding details, utility service drop design, etc). Also, see Appendix I for electrical outline specifications.

#### 2.6.5.1 Utility Service

As described in the system configuration, a single service will be provided by the utility via the existing 13.8 kV poleline that is currently routed around and through the site. The poleline was designed as part of the HWVP electrical design. The service will be routed underground via concrete ductbank to an outdoor pad-mounted transformer. A similar service was provided for the existing TWRS Office Building (TOB) as part of the HWVP electrical design and can be used as a basis. The pole selected for the service drop is contingent on the location of the service entrance equipment and will be selected during Detailed Design.

The utility service will be grounded per the WHC EU requirements. In other words, an equipment grounding conductor will not be routed with the incoming service. WHC EU follows the NESC, not the NEC. WHC EU is the NESC interpretive authority for the WHC/DOE.

DOE Order 6430.1A Section 1630-2.3.5 references Factory Mutual (FM) 5-4/14-8 as a requirement for the design of oil filled equipment near buildings. The document requires containment around oil filled equipment for fire protection. Containment around oil filled transformers is not a WHC EU requirement. Therefore, if no oil containment is wanted, WHC EU must obtain a waiver from DOE and provide direction. The direction not to provide containment should be obtained during the next phase of the design. The cost for the utility service does include the containment sump and will be removed from the estimate following receipt of the WHC directive.

#### 2.6.5.2 480 Volt Distribution System

The 480 volt distribution system is a radial distribution system with dual trains provided for maintenance purposes. The incoming utility supply is connected to the 480 volt service entrance switchgear. Utility metering will be provided at the switchgear. The utility metering requirements will be coordinated with the utility and provisions provided for the connection of the utility FDAS. The 480 volt switchgear will be double ended with a normally closed tie breaker. Provisions for connecting a portable utility generator will be provided on the bus opposite of the incoming utility supply for purposes of maintenance or utility failure. The switchgear will distribute power to the downstream 480 volt MCCs (SC2 & SC3) and to large loads 150 amps or greater.

The MCCs will distribute 480 volt power to the small 480 volt loads 1/2 hp and larger and to transformers supplying the 208/120 volt panelboards and Uninterruptible Power Supplies (UPSs).

480 volt lighting will be provided for the hi-bay HID lights in the operating area. The lighting circuits will be fed from circuit breakers and contactors located in the MCCs.

Miscellaneous 480 volt loads such as welding receptacles and specialty equipment such as carts and cranes will also be fed from the MCCs.

#### 2.6.5.3 208/120 Volt Distribution System

The 208/120 volt distribution system will be used to feed lighting and convenience outlets throughout the facility with the exception of the hi-bay lighting in the operating area. Emergency lights and exit signs will be powered from a dedicated 120 volt circuit per the NEC.

#### 2.6.5.4 Lighting

480 volt HPS hi-bay lighting will be used in the operating area. The operating area will be provided with 50 fc area lighting for crane operations with spacing between fixtures to comply with IES max/min and avg/min illumination ratios. Selected fixtures will be provided with instant re-strike capability to avoid blackout upon restoration of power following an outage. The HWVP lighting design contained in the HWVP Canister Storage Building design package E350 can be used as a basis for the fixture types, layout and details.

If required during Detailed Design, any additional street lighting or security lighting around the security fence will be accomplished using 480 volt supply and LPS fixtures (6430.1A Section 1650-2 requirement in areas around observatories). The lighting circuits will be direct buried. The HWVP Security Lighting and electrical design packages can be used as the basis for exterior area, security and street lighting designs. Lighting levels will be commensurate with the IES recommendations for street, area and security lighting.

120 volt fluorescent lighting will be used in offices and equipment rooms. Industrial fixtures will be used in the equipment rooms and commercial fixtures for the offices. Energy efficient lamp and ballast combinations will be used per the State of Washington energy policies. Dual level lighting will be provided in all locations. Offices will be provide with 50 fc and equipment rooms with 30 fc per the IES. Rooms with CRTs will be provided with louvered lighting to minimize glare during computer operation.

120 volt emergency lighting with 90 minute battery backup will be provided for all egress paths in accordance with the Life Safety Code. 12 volt maintenance free emergency lighting units will be used in areas supplied with HID lighting. Areas that utilize fluorescent lighting fixtures will utilize selected fixtures supplied with emergency fluorescent battery packs. All emergency fixtures will be provided with test switches and indicator lamps to facilitate maintenance.

Areas subject to decontamination such as the cask transfer tunnel will be provided with enclosed and gasketed fixtures suitable for wet locations. Narrow corridors such as the tunnel area will be provided with HID wallpack fixtures for contact maintenance when required.

Building exterior lights will be Low Pressure Sodium (LPS) wallpack units suitable for wet locations.

#### 2.6.5.5 Uninterruptable Power Supply (UPS)

UPSs will be provided for the DCS, HPS, SC2 controls and associated equipment. Additionally, essential equipment will be provided with uninterruptable power where it is determined that a loss of power can result in bodily injury, loss of essential continuous monitoring, or significant economic losses or downtime.

#### 2.6.5.6 DC Power Supply

DC power will be provided for the emergency generators (SC2) starting system.

#### 2.6.5.7 Construction Power and Communications

Construction power and communications will not be provided. The general contractor will be responsible for coordinating the construction power and communications with WHC.

#### 2.6.5.8 Grounding

A ground loop consisting of 2/0 copper conductor or equivalent capacity in steel cable will be provided around the building and bonded to the structural steel at approximately 30 foot intervals or every column whichever is greater. The service entrance equipment will be grounded per the NEC. The HVAC exhaust stacks will be provided with lightning protection as required per 6430.1A Section 1630-5. NFPA 78 will be used as a guideline for lightning protection. Ground fault protection and surge protection will be provided at the main switchgear to protect the bus against low level ground faults and surges due to lightning strikes. The 300 foot deep ground well to the water table required for HWVP is not a requirement for this facility. Additionally, there is not a requirement to tie the ground loop into the other nearby facilities. Equipment bonding will be in accordance with the NEC. The HWVP design package can be used as a basis for the grounding system and the HWVP Security Fence design package can be used to obtain fence grounding details if required. Each power circuit will be provided with an equipment grounding conductor. Metal raceway systems will not be used for the equipment ground.



#### 2.6.5.9 Conductors

Conductors will be copper with insulation rated for the temperature and environment. Conductor sizes No. 10 and larger will be stranded (Note that on HWVP, WHC received a waiver from the DOE Order 6430.1A, permitting the use of #10 AWG stranded conductors). The minimum conductor size for power will be No. 12, No. 14 for 120 VAC control circuits and No. 18 for low energy class 2 remote control and signal circuits. Communication conductor sizes will be per WHC communications requirements. Circuit separation between power, fire signal, communications and class 1, 2 and 3 remote control and signal circuits shall be in accordance with the NEC.

#### 2.6.5.10 Raceways

Indoor electrical circuits shall be routed in Intermediate Metal Conduit (IMC) for noncorrosive and non hazardous locations. Rigid steel galvanized conduit (RSG) will be used in areas where the conductors are may subject to physical damage. Raceways embedded in concrete shall be nonmetallic conduit.

The minimum size conduit shall be 1/2 inch minimum in diameter for aboveground locations. Conduits embedded in concrete shall be 2 inch minimum diameter.

#### 2.6.5.11 Spare Capacity

Switchgear, MCCs and panelboards shall be provided with 25% spare capacity for future load growth. The spare capacity for the pad mounted transformer will be determined via discussions with WHC EU during the next phase of design. Underground ductbanks will be provided with a minimum of 25% spare conduits, but not less than two. The incoming telephone cable will be provided with at least 50% spare circuits.

#### 2.6.6 Communication Systems Requirements

The following communication systems are required to support the facility operations:

- General Plant Telephone System (GPTS)
- Emergency Telephone
- Radio System for Fire Protection
- Data Highway for DCS
- Data Highway for HPS
- CCTV for Crane and MCO/Cask Transfer Tunnel Operations

- Hanford Local Area Network (HLAN)
- Public Address System
- Field Data Acquisition System (FDAS)

The following alarms will be provided:

- Fire
- Evacuation
- Radiation Hazard
- Take Cover
- Site Crash

The GPTS will provide tie-ins to the Hanford Site crash alarm and the emergency 811 telephone system. The crash alarm will be directed to selected plant phones. Telephones will be provided in all offices and operating areas. Offices will be provided with two telephone jacks on opposing walls.

The take cover alarm and evacuation alarm will be annunciated through the public address system. The alarms will be activated from the control room.

Radiation and hazardous condition alarms will be annunciated by means of the Health Protection Computer system.

Public address system coverage is required for all areas accessible to personnel, both interior and exterior. The PA system will be accessed by the telephone system.

HLAN data outlets will be provided next to every telephone outlet in each office and control room.

Fire alarm annunciation equipment will be located in the control room. Fire alarm pull station locations will be determined by the fire protection engineer. Fire alarm signals to offsite will be transmitted by radio.

The CSB telephone, HLAN and PA systems will be routed to the communication room which will consist of a telephone backboard and equipment racks for the PA and HLAN systems. The GPTS and HLAN systems will be routed underground in concrete ductbank from the existing TWRS building communication room to the CSB communication room. Coordination with the WHC Site Communications group is required during Detailed Design to establish the tie-in requirements.

#### 2.6.7 Room Sizes

Load schedules were developed for each piece of electrical distribution equipment and were used to develop the equipment elevations Figure 2-22 through 26 and dimensions. The equipment dimensions were used as the basis for sizing the electrical and communication equipment rooms (Figure 2-27 through 29). Generator room sizes, Figure 2-30 were based on SC2 loads and associated calculations (see load schedule).

## PROPOSED ELEVATIONS

MCC #1 SC2

|   |            |        |
|---|------------|--------|
| A | 15 HP      | SPARE  |
| B |            | SIZE 1 |
| C | 10 HP      | SPACE  |
| D |            |        |
| E | 10 HP      | SPACE  |
| F |            |        |
| G | CB      CB | SPACE  |
| H | L      R   |        |
| J | Main Lug   |        |
| K |            | SPACE  |
| L |            |        |
| M |            |        |

Figure-2-22

## PROPOSED ELEVATIONS

MCC #2 SC2

|   |            |        |
|---|------------|--------|
| A | 15 HP      | SPARE  |
| B |            | SIZE 1 |
| C | 10 HP      | SPACE  |
| D |            |        |
| E | 10 HP      | SPACE  |
| F |            |        |
| G | CB      CB | SPACE  |
| H | L      R   |        |
| J | Main Lug   |        |
| K |            | SPACE  |
| L |            |        |
| M |            |        |

Figure 2-23

## PROPOSED ELEVATIONS

MCC #3 SC3

|   |          |         |         |         |                 |                   |       |
|---|----------|---------|---------|---------|-----------------|-------------------|-------|
| A | 7.5 HP   | CB<br>L | CB<br>R | 1 HP    | 5 HP            | 40 HP             | SPARE |
| B |          |         |         |         |                 |                   |       |
| C | 15 HP    | 3 HP    | CB<br>L | CB<br>R | SPARE<br>SIZE 1 | 30 HP             | SPACE |
| D |          |         |         |         |                 |                   |       |
| E | CB<br>L  | CB<br>R | 1 HP    | 2 HP    | SPARE<br>SIZE 2 |                   | SPACE |
| F |          |         |         |         |                 |                   |       |
| G | 25 HP    | CB<br>L | CB<br>R | 2 HP    | 30 HP           | 480 V<br>LIGHTING | SPACE |
| H |          |         |         |         |                 |                   |       |
| J | Main Lug | 2 HP    | 1 HP    |         |                 | 480 V<br>LIGHTING | SPACE |
| K |          |         |         |         | SPARE<br>SIZE 3 |                   |       |
| L |          | 2 HP    | CB<br>L | CB<br>R |                 | SPACE             | SPACE |
| M |          |         |         |         |                 |                   |       |

Figure 2-24

## PROPOSED ELEVATIONS

MCC #4 SC3

|   |          |         |         |                 |                 |                 |                   |
|---|----------|---------|---------|-----------------|-----------------|-----------------|-------------------|
| A | 15 HP    | CB<br>L | CB<br>R | 1 HP            | 1 HP            | 40 HP           | 480 V<br>LIGHTING |
| B |          |         |         |                 |                 |                 |                   |
| C | CB<br>L  | CB<br>R | 2 HP    | 1 HP            | CB<br>L         | CB<br>R         | 480 V<br>LIGHTING |
| D |          |         |         |                 |                 |                 |                   |
| E | 25 HP    | 2 HP    | 1 HP    | SPARE<br>SIZE 2 | 30 HP           |                 | SPACE             |
| F |          |         |         |                 |                 |                 |                   |
| G | CB<br>L  | CB<br>R | 1 HP    | 2 HP            | 30 HP           | 5 HP            | SPACE             |
| H |          |         |         |                 |                 |                 |                   |
| J | Main Lug | 1 HP    | 1 HP    |                 |                 | SPARE<br>SIZE I | SPACE             |
| K |          |         |         |                 | SPARE<br>SIZE 3 |                 |                   |
| L |          | 1 HP    | 1 HP    |                 |                 | SPACE           | SPACE             |
| M |          |         |         |                 |                 |                 |                   |

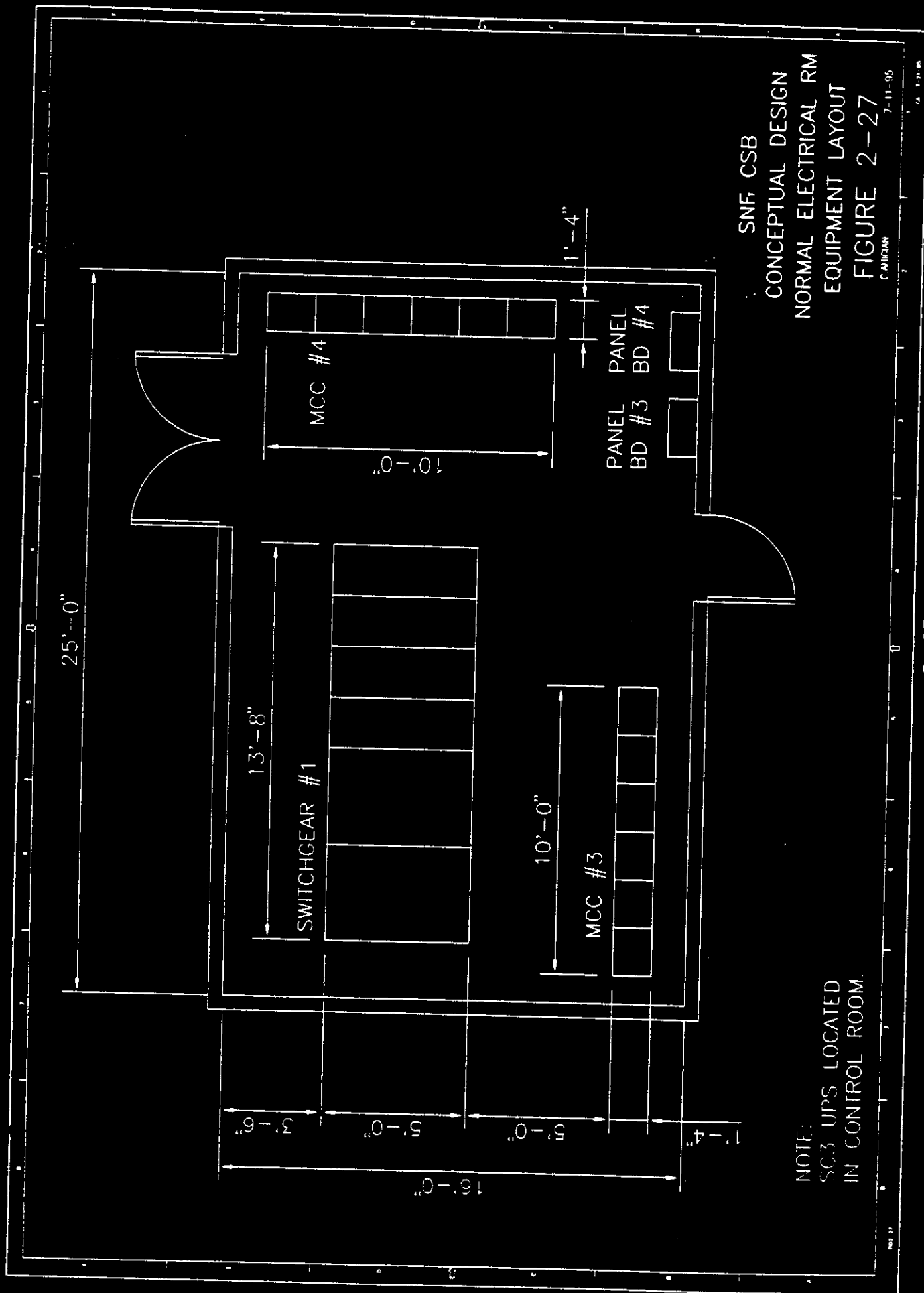
Figure 2-25

## PROPOSED ELEVATIONS

SWGR #1 SC3

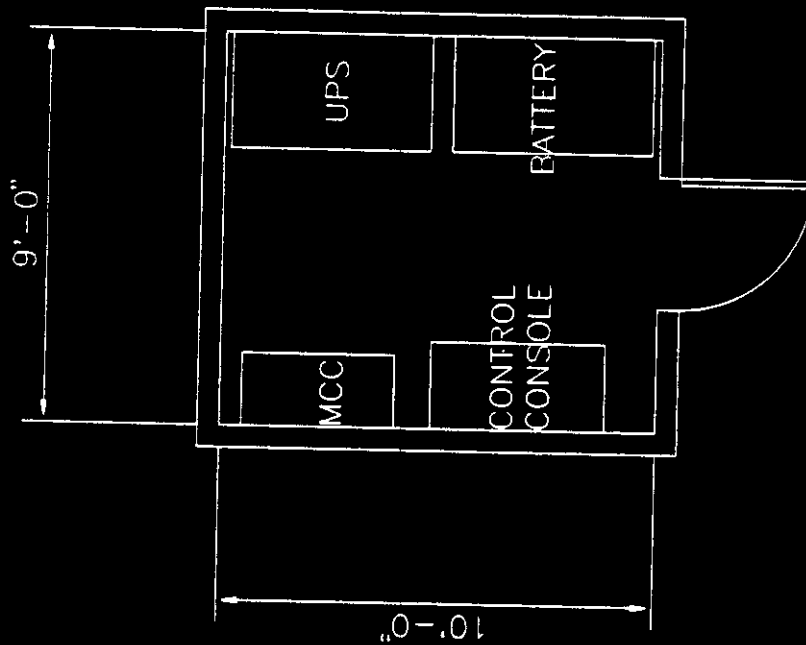
| INCOMING | UTILITY<br>METERING<br>SECTION | BLANK             | BREAKER<br>HEATING<br>208 kW | SPACE              | BLANK                          |
|----------|--------------------------------|-------------------|------------------------------|--------------------|--------------------------------|
|          |                                | MAIN<br>BREAKER   | BREAKER<br>SPARE             | BUS TIE<br>BREAKER | GENERATOR<br>TIE-IN<br>BREAKER |
|          |                                | BREAKER<br>MCC #2 | SPACE                        | SPACE              | BREAKER<br>MCC #1              |
|          |                                | BREAKER<br>MCC #4 | SPACE                        | BREAKER<br>SPARE   | BREAKER<br>MCC #3              |

Figure 2-26



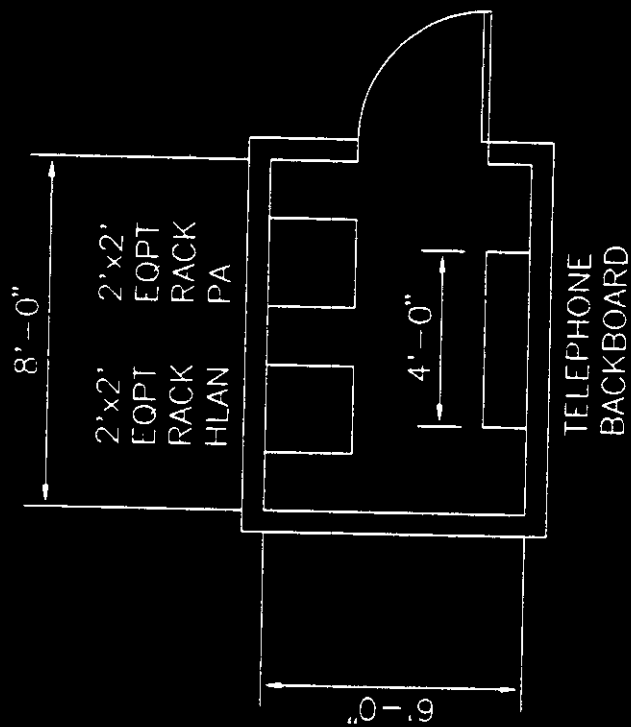
NOTE:  
SC3 UPS LOCATED  
IN CONTROL ROOM.

SNF, CSB  
CONCEPTUAL DESIGN  
NORMAL ELECTRICAL RM  
EQUIPMENT LAYOUT  
FIGURE 2-27  
7-11-85  
C. HANFORD



SNF, CSB  
CONCEPTUAL DESIGN  
SC2 ELECTRICAL RM  
EQUIPMENT LAYOUT  
FIGURE 2-28  
7-11-95

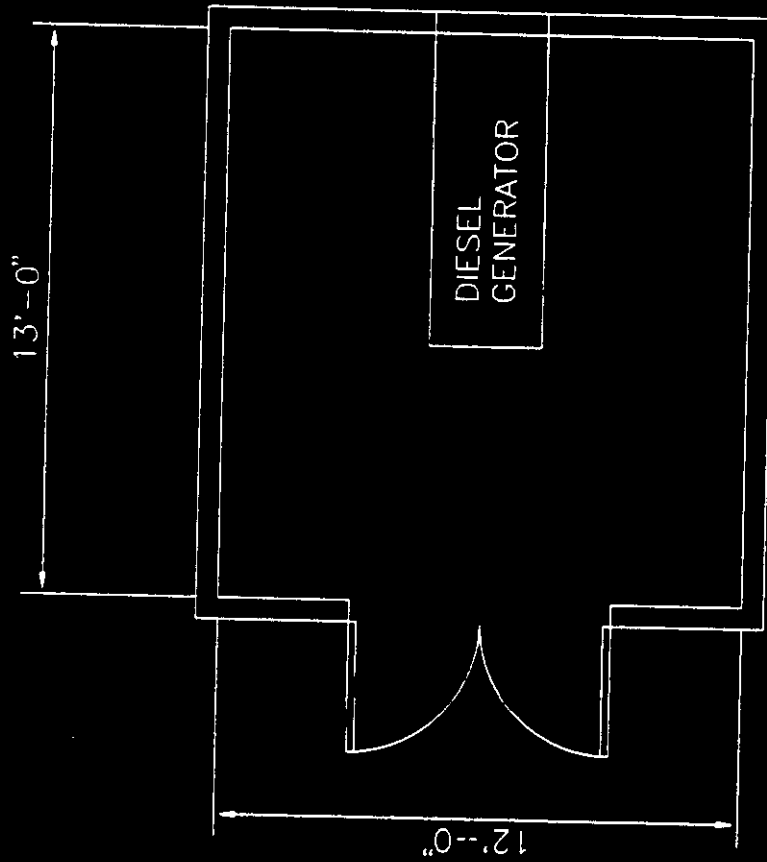




SNF, CSB  
 CONCEPTUAL DESIGN  
 COMMUNICATION ROOM  
 EQUIPMENT LAYOUT

FIGURE 2-29

7-11-95



SNF CSB  
CONCEPTUAL DESIGN  
GENERATOR ROOM  
EQUIPMENT LAYOUT

FIGURE 2-30

7-11-95

## 2.7 INSTRUMENTATION & CONTROLS

### 2.7.1 INTRODUCTION/SUMMARY

The following sections describes the total control, monitoring, alarming and emergency shutdown systems required to operate the Canister Storage Building and associated facilities. The intent of the control and monitoring/alarming system described is to provide operator control and monitoring of the facility from a single location except in emergency or maintenance situations. In emergency or maintenance situations local control panels are provided for operational and maintenance flexibility.

The major features of the system include monitoring of fire and safety systems and Health Protection systems and connection to the Hanford Site LANS, as well as control monitoring and alarming of the CSB storage vault, HVAC system and utility systems.

### 2.7.2 General Description

The Instrumentation and Controls (I&C) System provides the hardware and software required to monitor, alarm and control the plant operation. The I&C System interfaces with the HVAC, Health Protection (HP), Utilities, Fire and Safety systems, and the storage tube systems in the vault area through a high speed Distributed Control System (DCS). DCS reliability is enhanced with an Uninterruptable Power Supply (UPS).

Instrument and control hardware will interface to HVAC, utility systems, and the vault storage areas through Remote Terminal Units (RTU). The RTUs will interface to the Operators Console in the control room via redundant highway systems. The redundant highways will provide communication security between the operator CRTs and the remote control and monitor hardware. The I&C System consists of the following:

- Distributed control and monitoring system
- Storage Vault Temperature Measurement
- Building HVAC control and monitoring
- Safety Class 2 Control System
- Utility System control and monitoring

#### 2.7.2.1 Distributed Control System (DCS)

The DCS consists of closed loop control systems, monitoring and alarm generation. The control, alarm and monitoring are distributed throughout the plant in RTUs. The RTUs are connected to the operator console where control and monitoring is performed. Control loops control and monitor final control elements such as dampers and control valves. Flow, temperature, pressure and levels are monitored and measured. The DCS is capable of redundant

control and is powered by a uninterruptable power source.

The DCS design incorporates human factors engineered operator interfaces, standard software, and provisions for training and maintenance.

The DCS is connected to HP, Fire and Safety systems and Hanford Site LAN via communication ports (Hardware Interface Units) located on the data highway. The DCS is capable of providing interlocks and predesigned automatic response to emergency situations.

The I&C System incorporates a sophisticated alarm system in the DCS. The DCS alarm system is capable of providing various levels of audible alarm annunciation, alarm messages printed on CRT screens for operator action and alarm messages printed on the alarm printer for record keeping and failure analysis.

#### 2.7.2.2 Storage Vault Temperature Measurement

The I&C System will measure temperature in the following areas:

- Storage vaults
- Storage vault stack
- HVAC air handling units

Temperature measuring systems will use RTDs because of greater accuracy over the temperature range in the building. Vault temperatures will be measured using multiple RTDs in thermowells. Measurements will be taken at high, mid and low elevations. Stack measurements will be taken by multiple RTDs at high and low stack elevations. Temperature measurements in air handling units will be taken in inlet and outlet duct locations.

#### 2.7.2.3 Building HVAC Control and Monitoring

Building differential pressure measurement and control techniques will be used to maintain a negative pressure differential in the vault area. Office and maintenance area temperature control will be by local area thermostatic control loops. Critical air handling units will be interlocked such that standby air handlers can be automatically started in emergency situations.

#### 2.7.2.4 Safety Class 2 Control System

Redundant and independent hardwired Safety Class 2 Control panels will be located in the Safety Class 2 electrical rooms for control and monitoring of the Safety Class 2 HVAC confinement system for the operating area. The SC 2 Control system shall be completely independent of the plant DCS. The functions of the system are to provide a safe operating HVAC environment, alert the facility management system of a SNF CSB emergency, and provide audible and

visual personnel alarms for the operations personnel.

#### 2.7.2.5 Utility System Control and Monitoring

Utility systems shall be controlled, monitored and annunciated in case of failure. Systems shall be interlocked via the DCS as required.

#### 2.7.3 Communication

DCS communication is provided by a high speed redundant highway system as described in (Figure 2-31 "Preliminary DCS Communication Block Diagram"). The highway system can interface to the Hanford Site LANs via Highway Interface Units (HIUs). A HIU is also provided to interface to the facility Health Protection System.

Authorized site personnel can access monitored SNF CSB data via the plant LANs.

### 2.8 RADIATION PROTECTION

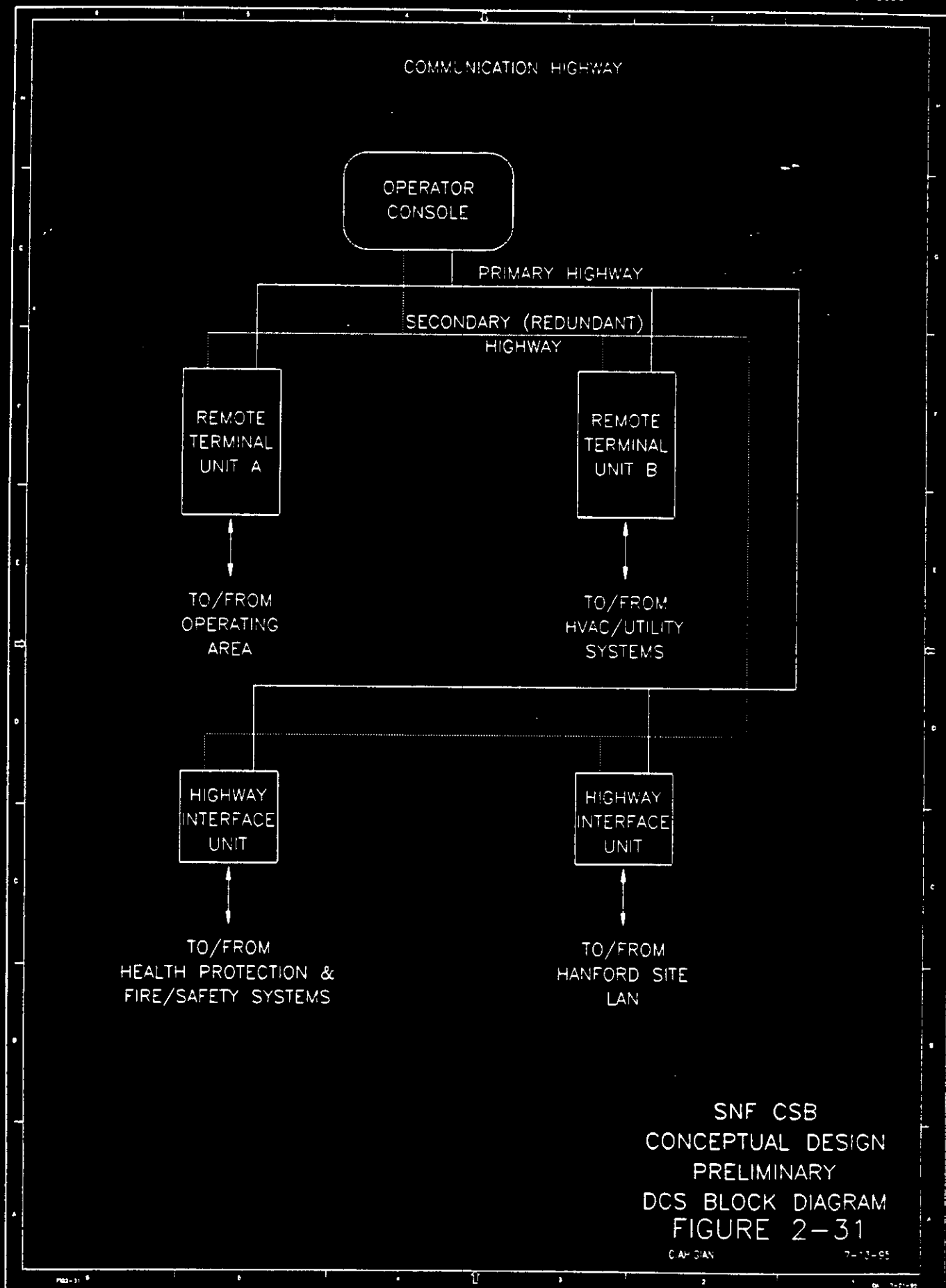
#### 2.8.1 Introduction/Summary

This section provides a Health Physics (HP)/Shielding review of the conceptual design of the Spent Nuclear Fuels (SNF) Canister Storage Building (CSB) as a staging and storage facility (SSF) for the N-Reactor fuel.

From a Health Physics standpoint the facility as designed for the Hanford Waste Vitrification Plant (HWVP) project is ideally suited for the storage of spent fuel. Some facility features have been altered in conceptual design in order to meet the latest DOE requirements such as DOE/EH-0256T, Radiological Control Manual, Rev. 1, April 1994. For example, the facility has been designed with change rooms, step-off-pads (SOPs), and a personnel decontamination area with emergency decon shower and body frisker. It should be noted that, at this time, these facilities are unisex since the small number of workers in the CSB does not justify segregated areas. In addition, the third vault will be completely shielded, isolated, and will remain empty for the life of the facility, if it is not completed before one and/or the second vault begin to be loaded.

#### 2.8.2 Facility Description And Evaluation

Although the CSB was designed in accordance with DOE 6430.1A, General Design Criteria, April 1989, which specified a yearly exposure for radiation workers of 1,000 mrem cumulative total effective dose equivalent (CTEDE), the Westinghouse Hanford Company (WHC) and the Fluor Daniel Inc. (FDI), Health Physics (HP) departments mutually agreed that this dose should be divided into



400 mrem/yr, whole body dose, and 600 mrem/yr for internal dose exposure. The DOE regulation cited above, in paragraph 2.8.1, limits the yearly CTEDE to radiation workers to 500 mrem. This means that the CSB is designed in compliance with the latest contemporary DOE regulations. The design of the operating floor meets the latest WHC requirements for a Radiation Access Zone (RAZ) 1 which permits 40 hours per week occupation.

The Radiological Control Manual (Rad Con) manual requires the HP facilities noted above in paragraph 2.8.1. In addition, the SOPs must be contiguous with the radiological areas that require radiation work permit (RWP)/special work permit (SWP) such as the cask handling, storage, preparation and operating areas.

If the third vault remains empty, without any ventilation airflow restrictions, then the preponderance of natural convection air, after stabilization, will flow through the empty vault and not through the MCO filled vaults. Flow restricters will be difficult, if not impossible, to remove if WHC finds a use for the vault at a later date because it is currently inconceivable that anyone will be able to enter the area after the first and second vaults are filled with MCOs. Even if the wall thickness between the second and third vault is increased, the effects of radiation scatter around the exhaust and inlet plenums will most likely produce a RAZ 5, which does not allow access. The third vault will remain in its current configuration until further direction is received.

The shipping cask will have to provide shielding against gammas, beta originated bremsstrahlung radiation and neutrons. The preliminary estimates without bremsstrahlung or neutrons indicate that the Max A MCO with an 8-inch steel shield will produce a contact dose rate of approximately 200 R/h. The actual shielding capacity of the 8 inch steel shipping cask requires further evaluation in regards to the definition of the density of the overall MCO. Since uranium is 2.4 times heavier than steel, it might be expected that the weight of the MCO, which contains uranium, would be higher than a solid steel MCO. However, based on the information provided by WHC, the MCO is 2.6 times lighter than an equivalent solid steel MCO. This means that the smeared density used by the MicroShield version 4.10 shielding code is less than that of steel. FDI Shielding investigated the contact dose rate using both the Monte Carlo Neutron Photon (MCNP) code and the MicroShield code. The results of this investigation are covered more rigorously in Appendix V.

The current plan to use an 8 inch steel shipping cask with no neutron shield places an enormous technical and cost burden on the design of the SNF CSB to remain in compliance with both of the DOE regulations cited above. For example, the entire north end of the facility is shielded to protect the inside workers as the cask bearing train or truck approaches. In addition, the Wash Down area

and the Load In/Load Out area are shielded to protect inside workers as well as personnel who are outside the facility when the shipping cask is inside the building. It should further be noted that this facility shielding includes approximately 20 shield doors. Four of these doors are large enough to permit railroad access. A list of these doors is in Appendix II. Also, the Wash Down area and the Load-In/Load-Out areas cannot be contact maintained when a loaded transport cask is present and are designed to be completely remote handled.

In accordance with the attached SNF CSB SSF ALARA Program, Appendix V, a preliminary ALARA analysis was performed for the three cases of a 20 mrem/h, a 0.5 mrem/h and a 0.2 mrem/h contact dose rate shielded cask. This ALARA analysis is also in the Appendix. The results of the ALARA analysis are that it is mandatory to design an optimized shield cask that will provide shielding against gammas, beta originated bremsstrahlung radiation and neutrons to a contact dose rate of 0.2 mrem/h.

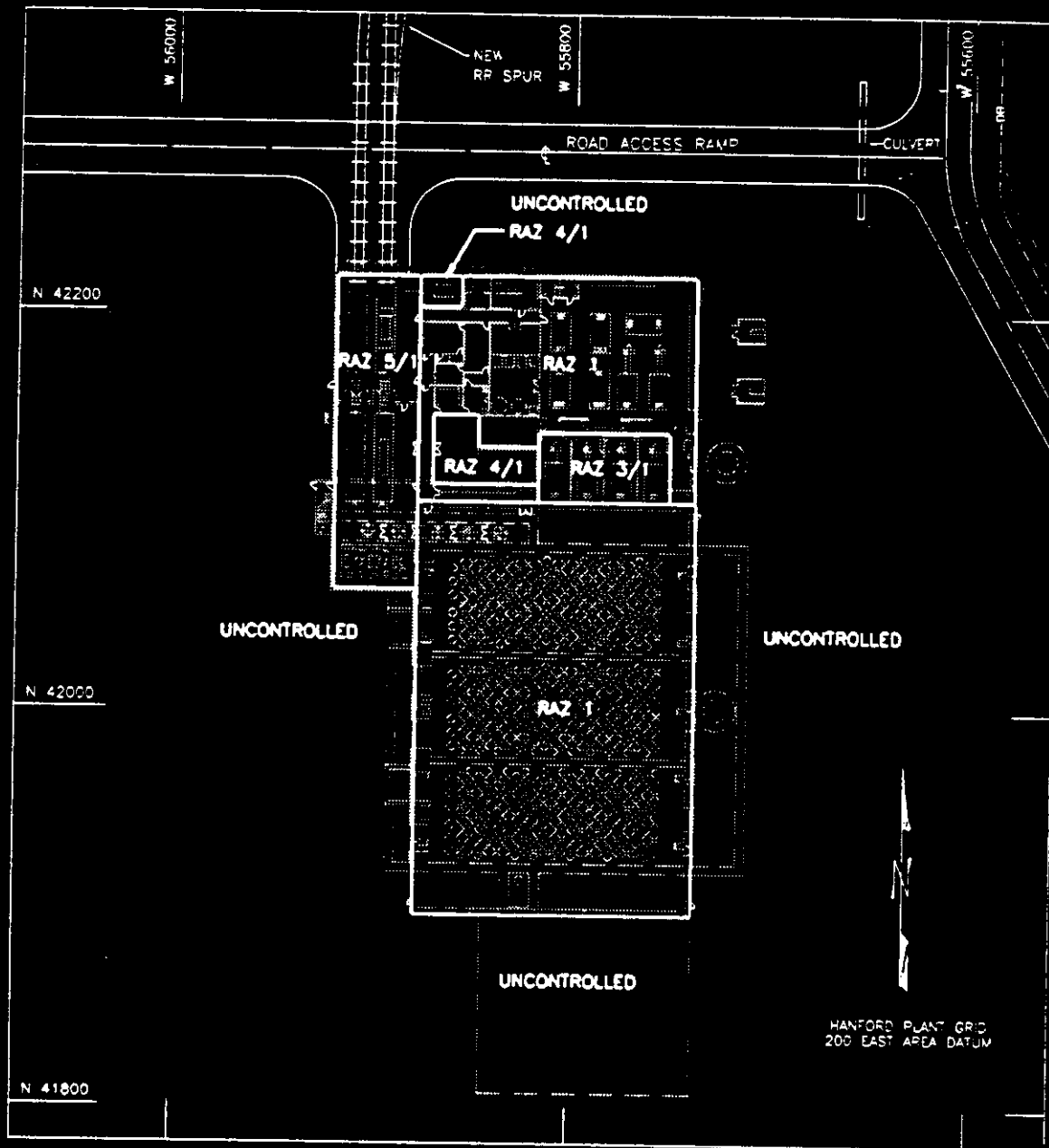
Figure 2-32 has been generated based on the results of the above referenced preliminary ALARA analysis identifying new RAZ boundaries. As can be seen, the new optimized shielding cask makes the SNF CSB operating floor RAZ-1. The Wash Down area and the Load-In/Load-Out area are still RAZ-5 and the balance of plant is a RAZ-1. The area immediately outside the plant is an Uncontrolled Area while the majority of the building remains a steel structure.

#### 2.8.4 Summary of Shielding Results

A number of shielding requirements and configurations have been analyzed during the Conceptual Design Phase of the CSB/SSF design. Those areas/items having potentially the most impact on the facility cost were given the highest priority for analysis. These included:

1. Handling cask shielding
2. Thicknesses of concrete walls (ordinary concrete)
  - 2.1 Wash Down/Load-In/Load-Out area
  - 2.2 Cask transfer tunnel
  - 2.3 Outside walls
  - 2.4 Vault walls, outside walls
  - 2.5 Vault walls, inside walls (for 3rd empty vault)
3. Operating floor thickness (ordinary concrete)
4. Wash Down/Load-In/Load-Out area ceiling (ordinary concrete)
5. Equipment shielding doors
  - 5.1 Railroad car access
  - 5.2 Shipping cask access
6. Personnel shielding doors
  - 6.1 Transfer tunnel access

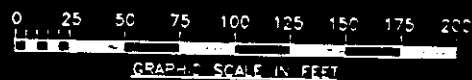




SHIELDING DESIGN CRITERIA

| ACCESS TIME ALLOWED        |                | DESIGN EXPOSURE RATE (UREM/HR) | ACCESS ZONE CATEGORY (NOTE 1) | TYPE OF RADIOLOGICAL AREA |
|----------------------------|----------------|--------------------------------|-------------------------------|---------------------------|
| FROM                       | TO             |                                |                               |                           |
| 40 HRS/WEEK                | 24 HRS/DAY     | 0.08                           | NOT APPLICABLE                | UNCONTROLLED              |
| 1 HR/DAY                   | 40 HRS/WEEK    | 0.2                            | 1                             | CONTROLLED                |
| 1 HR/WEEK                  | 1 HR/DAY       | 2                              | 2                             | CONTROLLED                |
| 10 HRS/YEAR                | 1 HR/WEEK      | 10                             | 3                             | CONTROLLED                |
| 1 HR/YEAR                  | 10 HRS/YEAR    | 50                             | 4                             | CONTROLLED                |
| NO NORMAL ACCESS PERMITTED | NOT APPLICABLE | (NOTE 2)                       | 5                             | CONTROLLED                |

NOTES  
1. NOT TO BE CONFUSED WITH HVAC VENTILATION ZONES  
2. NO SHIELDING REQUIREMENTS FOR PERSONNEL PROTECTION



SNF CSB  
CONCEPTUAL DESIGN  
RADIATION ACCESS ZONES

FIGURE 2-32

CALIFORNIA

7-17-85

The results of these shielding analyses are dependent on the radiation limits established for the facility. As indicated in the shielding criteria, the 40 hour-per-week radiation limit is 0.2 mrem/hour. Using this limit, the following shielding results were obtained for the above significant conceptual design areas/items (note: 2.24 g/cc density assumed for ordinary concrete):

- |                                            |                                      |
|--------------------------------------------|--------------------------------------|
| 1. Handling cask shielding *               | 12" Steel + 5" Poly + 1" Steel       |
| 2. Thicknesses of concrete walls:          |                                      |
| 2.1 Wash Down/Load-In/Load-Out area        | 18" inside, 24" outside              |
| 2.2 Cask transfer tunnel                   | 4.5 ft                               |
| 2.3 Outside walls                          | 24" (North side)                     |
| 2.4 Vault outside walls                    | 3.5 ft (minimum), 4.5 ft current CSB |
| 2.5 Vault inside walls                     | 3.5 ft (minimum), 3.0 ft current CSB |
| 3. Operating floor thickness               | 4.0 ft minimum                       |
| 3.1 Plug (with 1" steel)                   | 28.5" (2.24 g/cc concrete)           |
| 4. Wash Down/Load-In/Load-Out area ceiling | 18"                                  |
| 5. Equipment shielding doors (steel): **   |                                      |
| 5.1 Railroad car access                    | 4" inside, 5" outside                |
| 5.2 Shipping cask tunnel access            | 4" (middle door)                     |
| 6. Personnel shielding doors (steel) **    | 4" inside, 5" outside                |
| 6.1 Transfer tunnel access doors **        | 4" west end, 8" east end             |

\* Note: Additional shield optimization in Advanced Conceptual Design (ACD) may reduce the steel and/or polyethylene thicknesses required.

\*\* Note: See Equipment List (Appendix II) for listing of some 20 shield doors required, at least 15 of which are necessary due to the limited transport cask shielding

These values are used in the facility design layouts and for the Conceptual Design (CD) cost estimate.

## 2.8.5 Recommendations

FDI Shielding recommends that if the shielding capacity of the transport cask cannot be increased, then an additional, half-cylindrical shield permanently installed on the railroad car or truck should be considered. The transport cask would be installed in the lower half railroad car shield. The top half-cylindrical shield could then be installed and locked in-place on the original transport cask. This "double shield" would be used in the SNF CSB to provide shielding for the above-ground handling and MCO/Cask Transfer Tunnel handling of the MCO. This would eliminate all of the shielding in the SNF CSB except in the Load-In/Load-Out area and fifteen shield doors. If the transport cask could be designed in accordance with the optimized facility shield cask, then all of the shielding and all of the shield doors could be eliminated. This design would also eliminate the MCO/Cask Transfer Tunnel.

## **2.8.6 Open Items**

- 2.8.6.1 Direction is required regarding future use of the third vault, so that provisions can be made relative to HVAC and Shielding concerns as described in 2.8.2 above.

## **2.9 PROCESS ENGINEERING**

### **2.9.1 Introduction/Summary**

This section presents brief descriptions of the various utility systems which provide support for the operation of the SNF CSB. An overview of the required equipment is presented in Block Flow Diagram form in Figure 2-33. Additional details are provided for the individual systems - Instrument Air (Figure 2-34), Sanitary Water (Figure 2-35), Process Water (Figure 2-36), and Liquid Waste Collection (Figure 2-37), also in Block Flow Diagram form. MCO Monitoring and Servicing is also described.

### **2.9.2 Bottled Gases**

Gases used to purge and inert MCOs during servicing will be bottled and will be supplied as required for facility operation. Recommendations of the Compressed Gas Association (CGA 1984) will be used as applicable.

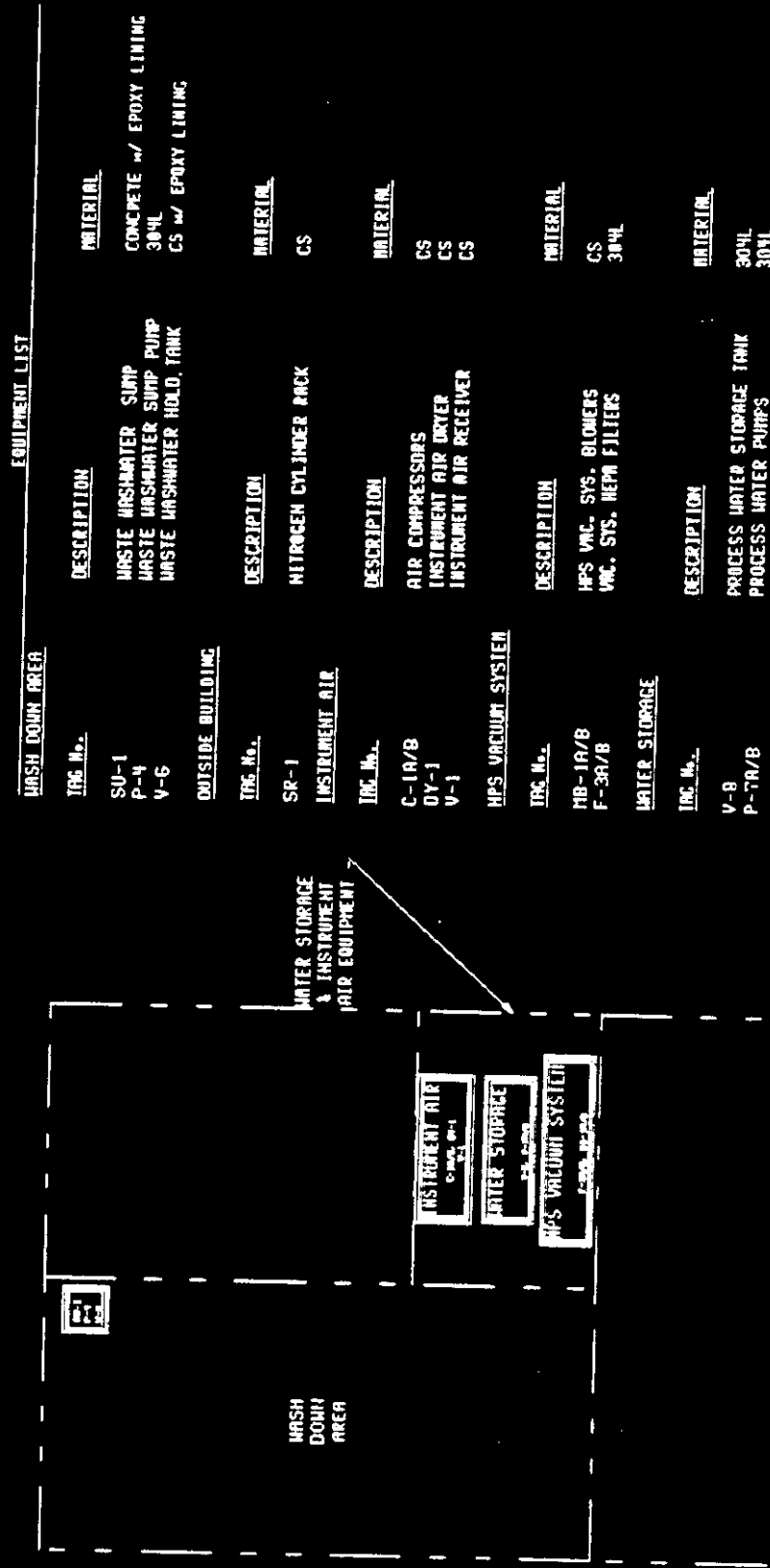
### **2.9.3 Instrument Air**

The Instrument Air System provides clean, dry, compressed air to pneumatic controls throughout the building. Figure 2-34 depicts the process flow. Compressed air (plant air) is also provided to utility stations. The plant air will have a sufficiently low dew point to prevent condensation from forming in the distribution piping. The system is comprised of compressors, an air receiver, dryer, piping, and controls and is located within the SNF CSB.

The system is designed to supply instrument air to users under the worst of two conditions: 1) the worst-case operating condition, and 2) the normal quantity of instrument air while providing normal air-powered hand tools with plant air. The system will distribute air to users at a nominal pressure of 100 psig, which is sufficient for contemplated uses.

Systems that use instrument air will be designed so that a loss of instrument air will result in a safe condition. It is typically not practical to design an air distribution system that is immune from accidental interruption, therefore, either instruments will default to a safe state upon loss of instrument air, or a back-up device will be installed locally.

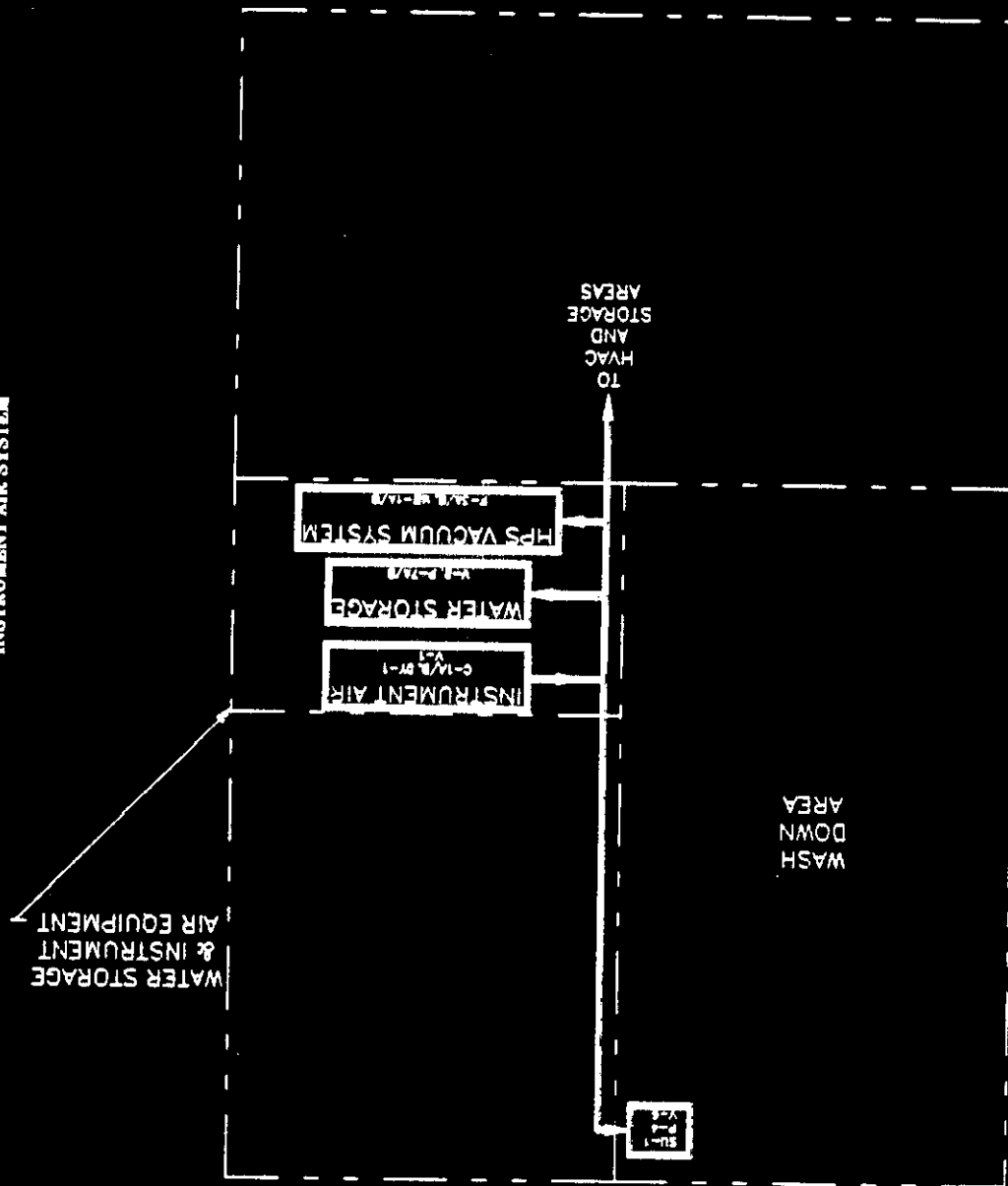
FIGURE 2-55  
 BLOCK FLOW DIAGRAM  
 OVERVIEW



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 WHC P.O. TVM-SVV-370252

Fluor Daniel, Inc.  
 Government Services  
 Contract 04436307

FIGURE 2-34  
 BLOCK FLOW DIAGRAM  
 INSTRUMENT AIR SYSTEM

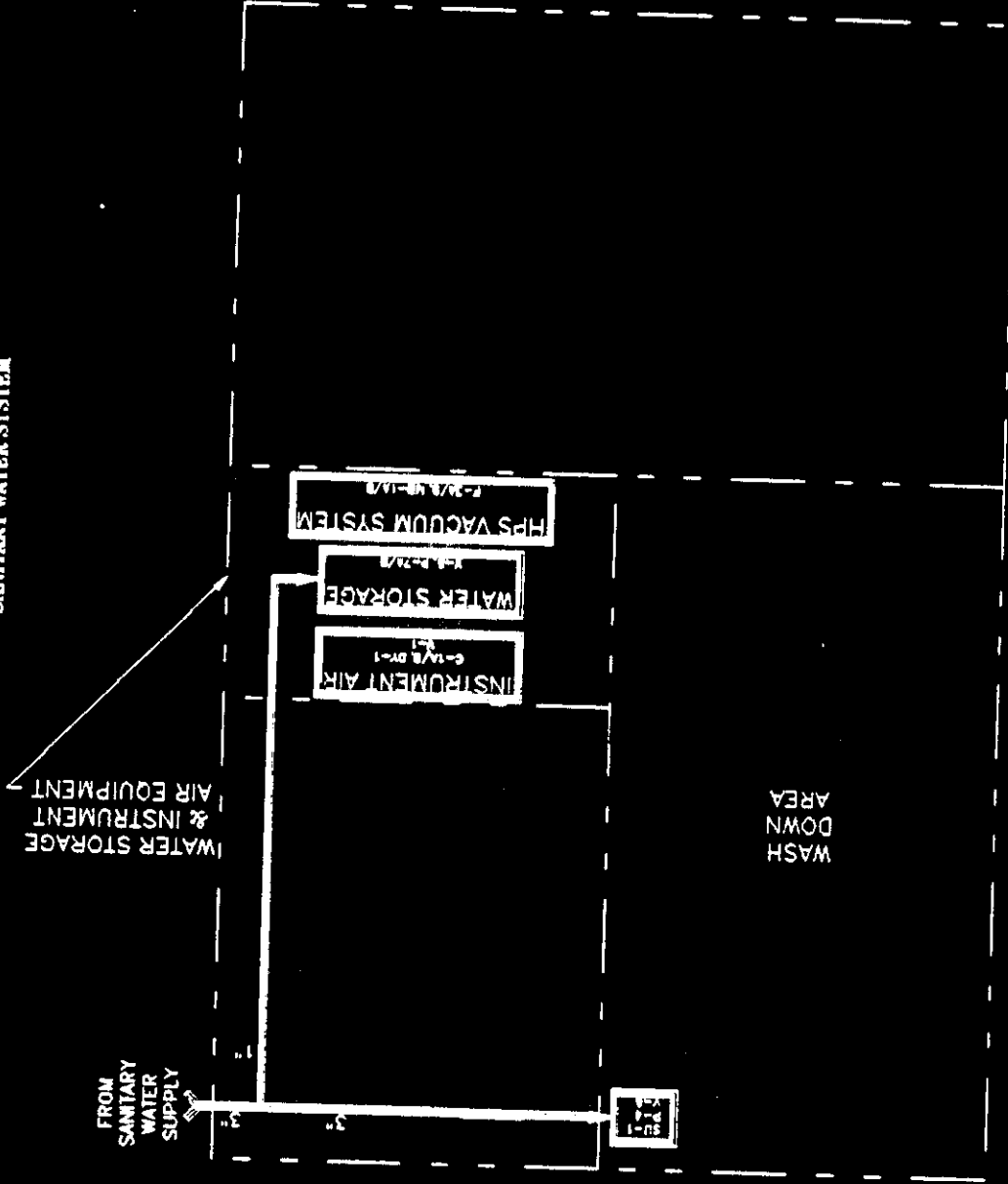


ALL PIPING IS CARBON STEEL  
 HEADER IS 2" - BRANCHES ARE 1"  
 DESIGN: 150 PSIG @ 200°F

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FIGURE 2-35  
 BLOCK FLOW DIAGRAM  
 SANITARY WATER SYSTEM

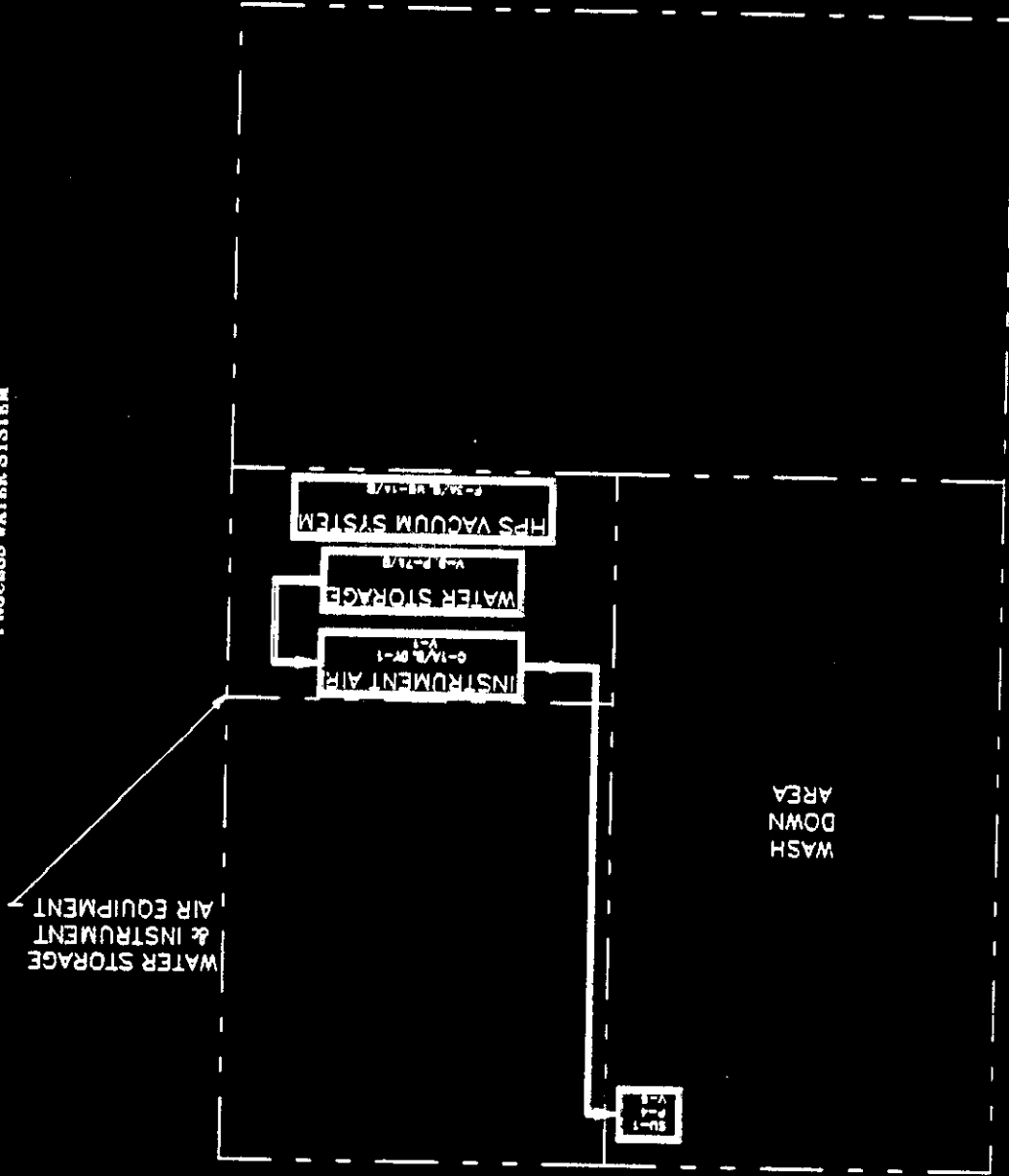


ALL PIPING IS CARBON STEEL  
 DESIGN: 150 PSIG @ 200°F

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 WHC P.O. TVM-SVW-370252

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 Contract 04436307

FIGURE 2-36  
 BLOCK FLOW DIAGRAM  
 PROCESS WATER SYSTEM

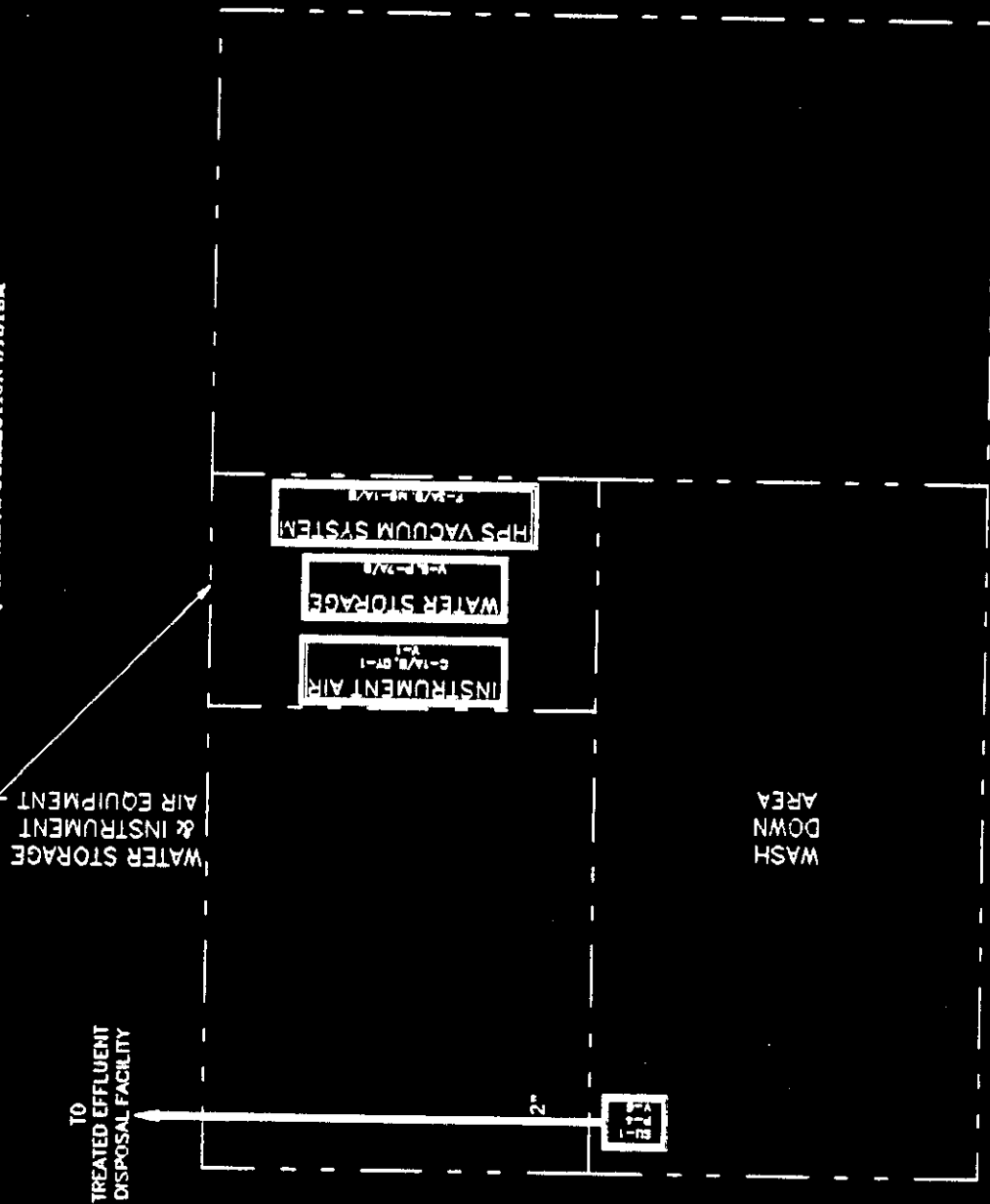


ALL PIPING IS 1" CARBON STEEL  
 DESIGN: 150 PSIG @ 200°F

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 WHC P.O. TW-SW-370252

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FIGURE 2-37  
 BLOCK FLOW DIAGRAM  
 LIQUID WASTE COLLECTION SYSTEM



PIPING:

ABOVE GROUND IS CARBON STEEL  
 UNDERGROUND IS POLYETHYLENE  
 DESIGN: 150 PSIG @ 100°F



## 2.9.4 Raw and Sanitary Water

2.9.4.1 General Description Fire (raw) Water and Sanitary (potable) Water mains exist to the east, west, and south of the proposed SNF CSB. The nearest location for connection is to the east of the building. The 12" raw water line and the 10" sanitary water line are approximately 100-200 feet away from the building in this area. Lines to serve the building from both of these systems will be constructed from the existing pipelines to the point of building connection. Also, the site raw water system will be extended to provide additional fire hydrant(s) around the building as required. Service lines into the building (except for Sanitary Water for purely domestic uses) will require backflow protection by means of air gaps or other approved means.

### 2.9.4.2 Water Uses and Design Decisions

2.9.4.2.1 Sanitary water is used to supply the plant facilities water needs (e.g., Wash Down, process water make-up). Figure 2-35 depicts the process flow. Sanitary water lines in the Wash Down area will be electrically-traced and insulated to allow operation for the removal of ice and slush from rail cars and trailers in winter.

2.9.4.2.2 Raw water will be used for fire protection and fire suppression purposes.

2.9.4.2.3 Process (sanitary) water will be provided for cooling water for the instrument air compressors. Figure 2-36 depicts the process flow. The small flow of water required for this purpose will flow through the cooling jackets into the liquid waste collection system. A process water storage tank will provide the air gap required for back-flow prevention.

### 2.9.4.3 Open Items

The design flow rate for Wash Down area equipment needs to be supplied by WHC prior to Detailed Design phase, as this equipment is to be specified by WHC.

## 2.9.5 Liquid Waste Collection

### 2.9.5.1 System Description

The Liquid Waste Collection System collects drainage from process water usage and miscellaneous sources of collected water from uncontaminated areas. Figure 2-37 depicts the process flow. Collected drainage is held in a tank for monitoring before it is

sent to the Treated Effluent Disposal Treatment Facility line at the site. The system is comprised of a piping network with sumps, holding tanks, pumps, and controls.

#### 2.9.5.2 Clean Drain to Treated Effluent Disposal Facility (TEDF)

A Clean Drain (DRX) pipeline is located along the east boundary of the site, in parallel with the sanitary and raw water mains described above. This pipe was installed as part of the HWVP project also, but has remained unused due to changes in the HWVP construction scope. Another portion of the unused DRX pipeline system is located to the north of the SNF CSB site and extends east toward B-Plant to a point just outside the HWVP site security fence.

The present project requires an operative DRX system to carry away effluent from the rail car Wash Down area (where dust and dirt are washed from the exterior of incoming rail cars, trucks, and transport casks), and from other miscellaneous sources. This water will be captured in a holding tank and checked for contamination prior to release to a sump outside the building, where a pump will pump the water to the 200E TEDF. To accomplish this, the existing unused DRX system within the HWVP site will be reconfigured so that the pump near the SNF CSB will pump the effluent water into the DRX line that extends to the east beyond the HWVP security fence. From that point, the DRX line will extend approximately 1350 feet east to connect to the existing B-Plant effluent system which is connected to the TEDF. An additional feature of this system will be a small Sample Building required by TEDF to sample the liquid effluent being discharged to the TEDF.

#### 2.9.5.3 Performance Objectives

- 2.9.5.3.1 The system will be sized based on 120% of the greatest demand from the process water system and miscellaneous sources such as condensed moisture or draining lines for maintenance. The Liquid Waste Collection System design rate will include the use of sanitary water to Wash Down the receiving area and process water to cool the instrument air compressors.
- 2.9.5.3.2 The system will be designed to minimize decontamination problems.
- 2.9.5.3.3 The design of drain lines will account for any difference in room pressures between different branches of the collection system.
- 2.9.5.3.4 The effect of firewater on the system has to be considered. Depending on system capacities, the sump could overflow. The effects and response to this

situation will be considered further during Advanced Conceptual Design.

#### 2.9.5.4 Design Decisions

2.9.5.4.1 All hazardous wastes from maintenance or special operations will be collected in portable containers and kept out of the liquid waste collection system.

#### 2.9.5.5 Open Issues

2.9.5.5.1 WHC should identify any specific design features required to meet Hanford standards for monitoring clean drain water sent to the TEDF.

2.9.5.5.2 WHC is to provide detailed information on the size and required components of the TEDF sample building, as this is a relatively new TEDF requirement.

#### 2.9.6 Sanitary Sewer

At present, no toilets or other sanitary facilities are planned for inclusion into the SNF CSB itself. WHC has proposed that these facilities will be provided by using adjacent facilities (either existing or proposed) outside the scope of this SNF CSB Conceptual Design Report. At the present time, WHC is proposing to use a separate latrine trailer with a holding tank that will be pumped out periodically. As a result, no sanitary sewer facilities are shown here.

Should sanitary sewer service be required at some time in the future, however, sanitary sewer collection and treatment facilities do exist to the north of the proposed building location. The nearest feasible point of connection is approximately 850 feet to the north. An extension of the existing sanitary sewer collection system could be designed to be constructed from that point south to the point of building connection. WHC has expressed the possibility that restrooms will be provided in a separate latrine trailer (not in the Conceptual Design scope), in which case sanitary service may be needed. WHC is also exploring (as mentioned above) the possibility of using a latrine trailer in conjunction with a holding tank that would be pumped out periodically. This alternate scheme would be dependent upon State of Washington approval of the toilet facility as a temporary facility. A fourth alternative would involve construction of a separate sewage collection and disposal system that would only serve the SNF CSB. In this case, a septic tank and drainfield would be located in the south portion of the HWVP site adjacent to the SNF CSB. WHC has agreed to provide specific direction on this item, as to whether sewer service is needed, and if so, which alternate is to be followed. These alternates will be investigated

during Advanced Conceptual Design. As indicated above, however, no sanitary sewer has been included at this time since it is outside the present scope of the SNF CSB itself.

## 2.9.7 Health Protection System (HPS) Vacuum System

### 2.9.7.1 System Description

The HPS Vacuum System provides vacuum for continuous air monitors and record air samplers in the building Health Protection System. The Health Protection System will warn plant personnel of hazardous radioactive conditions which may result from malfunctions or accidents. The HPS Vacuum System is comprised of blowers, HEPA filters, piping, and controls.

### 2.9.7.2 Performance Objectives

The system will provide vacuum to users at an estimated pressure of 4 psia. The estimated volumetric capacity of the system is 110 ACFM. Actual pressure and volumetric capacity of the system will be determined by the design of the Health Protection System.

### 2.9.7.3 Design Decisions

There are no Safety Class 1 or 2 monitors connected to the vacuum system. All necessary health protection alarms and data recording are protected by the UPS. Therefore, the HPS vacuum system does not need to function after loss of power or Safety Class 1 or 2 design basis accidents.

## 2.9.8 MCO Monitoring and Servicing

### 2.9.8.1 System Description

The MCO Monitoring and Servicing System provides early warning of developing problems with any of the MCOs in the normal storage tubes or overpack tubes, for the purpose of preventing safety problems that are not already detected by the Health Protection System. The MCO Monitoring and Servicing System will check the MCO pressure and surface temperature. There will be provisions for sampling the gas from the MCOs. Other functions may be added to this system, after an analysis of the credible problems from out-of-specification MCOs. The types of concerns are: high MCO temperature, MCO over-pressure, excessive hydrogen generation, and contamination of the spent fuel by water or other chemicals. After the MCO design details are determined, these concerns will be reviewed to determine and quantify the preventable problems that could credibly occur during staging and storage. The Monitoring and Servicing System will be designed to detect and prevent those problems.

## 2.9.8.2 Performance Objectives

The maximum allowable MCO temperature is 400 °F.

The MCOs shall be stacked two levels high in the storage tubes with impact absorbers below each MCO. The impact absorbers will be designed to decelerate an MCO dropped from two feet above the operating deck to the bottom of the tube.

## 2.9.8.3 Design Decisions

2.9.8.3.1 To prevent MCO over-pressure, the MCO vent valve will be opened at the MCO service station (located in the MCO/Cask Transfer Tunnel), before the MCO is placed in a tube for staging. When this is done, the pressure of the MCO will be measured, and there will be provisions for sampling the gas in the MCO.

The surface temperature of the MCO will be monitored as it is lifted out of the cask.

Inert gas will be provided for MCO servicing, so that if an out-of-range MCO is found, it can be purged and returned to K-Basin if necessary. The inert gas is provided by tubing connected to gas cylinders mounted outside the building (accessible for truck delivery).

2.9.8.3.2 With the present design, it is possible to gather information on the MCOs in their tubes using a cart that would be manually operated in the operating area. It is possible to sample the gas from a tube periodically or insert instruments into the tube, using the valved tubing in the plug. Gas measurements from the tube will be more useful if baseline measurements have been established for the first MCO in the tube before the second MCO is introduced.

2.9.8.3.3 It is expected that an excessive heat or hydrogen generation rate will diminish with time as residual water is consumed. If an MCO generates excessive hydrogen, temporary measures may suffice, such as placing the MCO in a tube by itself until the hydrogen generation rate decreases to normal.

If the heat generation rate of an MCO is excessive, moving the MCO to a cooler location in the vault can provide marginal improvement in the temperature. A more expensive way to provide a dramatic improvement in temperature is the addition of an inert heat transfer fluid into the tube space.

2.9.8.3.4 Direct measurements from the MCOs while in the tubes is difficult, expensive, and introduces opportunities for system-wide failure. Therefore, direct measurement of individual MCOs will be pursued only if necessary and if there are no suitable alternatives for avoiding credible accidents having on-site or off-site consequences.

#### 2.9.8.4 Open Issues

The hazards of leaving the MCO valves open during staging have not been fully analyzed.

## 2.10 FIRE PROTECTION ENGINEERING

### 2.10.1 Introduction

The main portion of the Fire Protection System is a water sprinkler system. Raw water at the site provides the source for fire water, which is distributed within the building. The uranium metal fuel, which will be stored in the building within containers, is combustible under certain conditions during the staging phase of operation. During the beginning of staging, the fuel generates hydrogen. After the fuel is stabilized, it is non-combustible and produces no hydrogen. Other combustible material in the building includes electrical insulation, wall coatings, lube oil for equipment, maintenance materials, and portions of the train cars and truck trailers that bring the MCOs into the facility. The fire protection system is comprised of a piping network with controls.

### 2.10.2 Performance Objectives

The building is protected throughout by an automatic wet pipe sprinkler system except for the vault storage area and the operating area over the vault in accordance with the requirements of NFPA 13. Areas which are subject to low temperatures will be freeze protected. A preliminary estimate of the pressure and flow requirements is 90 psi and 1000 gpm residual at the base of the sprinkler riser. Automatic smoke and/or heat detectors will be provided in the electrical switchgear and control rooms. The building will be provided with an automatic and manual fire alarm system with local evacuation signals in accordance with the requirements of NFPA 70 and 72.

### 2.10.4 Design Decisions

The fire protection system design is based on the previous design used for the HWVP CSB. The sole exception is that no sprinkler system is provided in the operating area over the vault, since a large transporter with rubber tires and contained fuel is not used in this design. The mitigation of water runoff from this area and

possible leakage into the storage tubes are areas of concern for the facility.

#### 2.10.4 Open Issues

2.10.4.1 It is not known whether the MCOs will release hydrogen continuously during the beginning of staging, or in bursts; the maximum instantaneous flow rate per MCO depends on the design of the MCO venting device.

2.10.4.2 Information is needed concerning the combustible materials associated with the truck, train, and cask used to bring the MCOs into the facility. The casks may have polyethylene shielding protected by steel.

### 2.11 SAFEGUARDS AND SECURITY

#### 2.11.1 Introduction/Summary

The SNF CSB will be protected by multiple layers of access control including the HWVP guardhouse and the inner SNF CSB security fence gate which will control access to the site. Entry control to the building and badging/lock, systems at inner radiation areas will allow only authorized access. Material accountability procedures will control access to and handling of radioactive or other materials where control is deemed necessary.

#### 2.11.2 Criteria

The security features incorporated into the conceptual design are intended to be functionally equivalent to the requirements of 10 CFR 73.67.

#### 2.11.3 Facility Description

The SNF CSB site area will be segregated from the remainder of the overall HWVP site by means of a chain link security fence, depicted on the Master Site Plan Figure 2-1. The new fence will be erected within the existing HWVP Site security fence, and will create a new controlled access area surrounding the CSB site. The fence line will be illuminated with 480 V LPS lamps, installed at intervals sufficient to support surveillance and detection, in accordance with IES guidelines. The existing 200E and HWVP security fences feature both inner and outer patrol roads.

Access will be controlled from the existing guardhouse on the western perimeter of the site. The guardhouse will be provided with telephone and hand held radio communication systems. The layout at the existing guardhouse provides space to conduct random vehicle and package searches without disrupting the flow of vehicular or pedestrian traffic through the gate.

Access to the radiation areas within the CSB will be controlled by a badging and lock system administered by the Health Physics organization. Access to these areas will be limited to authorized or escorted individuals, instrumented with suitable personnel dosimetry, and monitored by CCTV in the control room and/or HP area. Access to the vault interior via the natural convection air intakes is inhibited by locating them high above grade, and installing physical barriers designed to exclude wildlife species indigenous to the Hanford Site Area.

The procedures for material accountability and for responding to security threats should be detailed in a WHC Safeguards Contingency Plan, which for obvious reasons must have limited distribution, and is not included within this Conceptual Design Report.





### 3.0 COST ESTIMATE

The Spent Nuclear Fuel (SNF) Canister Storage Building (CSB) capital cost estimate was prepared as a "bottoms up" estimate based on the scope of work provided by the Conceptual Design Report (CDR). Quantity take-offs were obtained from sketches developed by engineering disciplines in support of the estimate. Equipment requirements were obtained from the equipment list and pricing developed from informal vendor quotes and in-house information.

Craft labor rates were obtained from the current Hanford Site Stabilization Agreement (HSSA) burdened craft wage rate chart dated May 30, 1995, prepared by ICF Kaiser Engineers, Hanford. Specific information regarding the conceptual design estimate criteria, methodology, format and coding is found in Section 3.1, Estimate Basis.

The estimate summaries and detail are located in Sections 3.2 and 3.3, respectively, the Budget Authorization/Budget Outlay (BA/BO) schedule is found in Section 3.4.

#### 3.1 ESTIMATE BASIS

The Estimate Basis is subdivided into four subsections:

- Estimate criteria, describes the assumptions & methodology used in developing the Conceptual Design Estimate.
- Basis of Material Take-Off (MTO), describes the approach, content and methods used to arrive at estimate line item quantities.
- Estimate format and coding, defines the estimate organization, hierarchy, and coding developed to structure the estimate in accordance with the Facility Code and Project Work Breakdown Structure (PWBS).
- References, lists the drawings, Equipment List and other documents used in the preparation of the estimate.

##### 3.1.1 Estimate Criteria

The Conceptual Design Estimate is structured to the following major subtotals:

- Direct Costs
- Indirect Costs
- Escalation
- Contingency

### 3.1.1.1 Direct Costs

The direct costs of the facility are defined as the following capital costs, which are estimated to be expended in the construction of the permanent plant facility:

- Direct labor
- Contractor's construction equipment
- Contractor procured equipment and material
- Construction Manager Procured Equipment
- Sales tax
- Contractor's overhead, profit, bond and insurance
- Business and occupation tax (B&O)

#### 3.1.1.1.1 General Assumptions

The following general assumptions and methods are used in the preparation of the SNF CSB Project Capital Cost estimate:

- A) All direct costs are expressed in 3rd Quarter GFY 1995 dollars (July, 1995).
- B) No project mission change or major rework will occur during the engineering and construction of the facility.
- C) No radioactive or otherwise contaminated soil, or underground obstructions, will be encountered during excavation for the facility.
- D) The estimate assumes all construction is Fixed Price.
- E) The estimate is based on a standard 40 hour workweek.
- F) Craft labor rates (journeyman) used are in accordance with the prevailing Hanford Site Stabilization Agreement. The labor rates include all applicable union fringe benefits and state and federal legislated benefits and burdens.
- G) Crew rates are developed for each CSI division and subordinate element of work by mixing the applicable craft and construction equipment rates.
- H) All equipment, machinery, and bulk materials are assumed to be U.S. purchased.
- I) All engineered machinery and equipment pricing is obtained by engineering specialists from informal vendor quotes and in-house cost data. Prices include freight to job site.

- J) Bulk material pricing is obtained by the estimators using current in-house material pricing data. Prices include freight to job site.
- K) Construction support facilities are estimated based on the following assumptions:
- Office trailer space for Construction Engineering, Inspection, Construction Management, Project Management and DOE personnel is assumed to be existing and available at the site for this projects requirements.
  - The warehouse at the site is assumed to be available for this projects equipment storage requirements.
  - The existing laydown areas at the site are assumed to be available for bulk material storage.
  - Fixed Price contractors will supply temporary facilities to meet their own staffing, material storage, and utility requirements. Water and power are assumed to be available at a central point on-site for contractor tie-in.
  - Utility water and power are assumed to be available from existing Hanford facilities for supply during the SNF CSB construction.
- L) New Sample Building - The requirements for the New Sample Building, shown on the plot plan as external to the CSB, were undefined at the time the estimate was prepared. The following assumptions were made to provide a basis for the estimate:
- 15' x 15' metal building on a concrete slab
  - Building was provided with an allowance for power, lighting, and fire protection
  - Building houses two sample pumps and sampling equipment estimated at \$5,000
- M) The Washington State (Benton County) sales tax rate of 7.8 percent is applied to all material and equipment purchases, and construction equipment usage. The sales tax calculation is included in the material and equipment columns of the estimate.
- N) The Washington State Business and Occupation (B&O) tax rate of 0.515 percent is applied to all direct costs. The B&O tax

calculation is included in the overhead, profit, bond and insurance column of the estimate.

- O) Fixed price contractor's overhead cost is estimated to be 34 percent of direct labor.

The contractor's profit, bond and insurance is estimated to be 6 percent of labor, overhead, equipment usage (construction equipment rental), and plant equipment and material (including 7.8 percent sales tax).

See Table 3-1 for the breakdown of contractor's overhead, profit, bond and insurance.

- P) The following costs were excluded from the scope of the capital cost estimate;

- All capital, start-up and operating spare parts
- Special work procedure (SWP) construction
- Transfer tunnel carts to and from the future Stabilization Facility
- Storage tube impact limiters (expense funded)
- MCO Handling Machine Cask (CK-1, expense funded)
- Start-up costs
- Expense funded costs
- Operating costs
- Decontamination and decommissioning (D&D) costs.

### 3.1.1.2 Construction Detail

The following quantity abbreviations are used throughout the estimate for all construction estimate line items.

| <u>Description</u>      | <u>Unit Abbreviations</u> |
|-------------------------|---------------------------|
| Excavation and Backfill | CY = Cubic Yards          |
| Roads (Surface)         | SY = Square Yards         |
| Railroad Track          | LF = Linear Feet          |
| Fencing                 | LF                        |
| Duct Bank               | CY                        |
| Concrete                | CY                        |
| Structural Steel        | Tons                      |
| Building Steel          | Tons                      |

|                                |                  |
|--------------------------------|------------------|
| HVAC Ductwork                  | Lot              |
| Machinery and Equipment        | EA = Each        |
| Pipe                           | LF               |
| Valves                         | EA               |
| Conduit and Wire               | LF               |
| Instruments                    | EA               |
| Paint                          | SF = Square Feet |
| Insulation                     | SF               |
| Miscellaneous Individual Items | EA               |
| Miscellaneous Allowances       | Lot              |
| Miscellaneous Composites       | Lot              |

Individual standard manhour unit rates of installation were developed for each CSI Division of labor in accordance with the Conceptual Design estimate coding structure (see Section 3.1.3, Estimate Format and Coding). The manhour unit installation rates are all-inclusive rates. These rates account for installation labor and general prorate direct labor such as offloading and storage of materials, scaffolding and cleanup. Material take-off (MTO) allowances are included in the unit rates to allow for damage and loss.

The following assumptions and MTO allowances are used in the development of the construction manhour and material unit installation rates:

- Civil Work - Neat quantities are taken off; a slope of 1.8 to 1 is used on all excavation quantities, and a 15 percent swell factor is used for backfill quantities. Since excavated soil is assumed suitable for backfill, no imported backfill is included. A disposal site was assumed to be within one-half mile of the construction.

- Concrete - Neat quantities are taken off, and rounded off to the nearest 10 cubic yards.

Concrete installation labor units include fabrication, installation and stripping of form work, installation of rebar or wire mesh, and pouring and finishing of concrete.

- Steel quantities are taken off and rounded to the nearest ton. An MTO allowance of 5 to 10 percent is allowed depending on the type of steel take-off:

|                |           |
|----------------|-----------|
| Light          | Qty + 10% |
| Medium         | Qty + 7%  |
| Heavy          | Qty + 5%  |
| Siding/decking | Qty + 10% |

Steel material pricing is developed from current in-house information.

TABLE 3-1

PROJECT COST ESTIMATE

FIXED PRICE CONTRACTOR

Overhead, Profit, Bond and Insurance, B&O Tax Calculation

|                                                                               |              | <u>% of Direct Cost</u>         |                                         |  |
|-------------------------------------------------------------------------------|--------------|---------------------------------|-----------------------------------------|--|
|                                                                               |              | Equipment<br>Usage <sup>2</sup> | Equipment<br>&<br>Material <sup>3</sup> |  |
| <u>Overhead</u>                                                               | <u>Labor</u> |                                 |                                         |  |
| Temporary Facilities, Cleanup<br>and Support Services<br>Personnel Protection | 8%           |                                 |                                         |  |
| Utilities                                                                     |              |                                 |                                         |  |
| Weather Protection                                                            |              |                                 |                                         |  |
| Area Maintenance                                                              |              |                                 |                                         |  |
| Small Tools and Consumable                                                    | 6%           |                                 |                                         |  |
| Field and Home Office Staff <sup>1</sup>                                      | 15%          |                                 |                                         |  |
| Contractor QA/QC Staff                                                        | 5%           |                                 |                                         |  |
| Total Overhead                                                                | 34%          | 0%                              | 0%                                      |  |
| <u>Profit</u>                                                                 | 5%           | 5%                              | 5%                                      |  |
| <u>Bond and Insurance</u>                                                     | 1%           | 1%                              | 1%                                      |  |
| Total Profit, Bond and<br>Insurance                                           | 6%           | 5%                              | 6%                                      |  |
| <u>Washington State B&amp;O Tax</u>                                           | .515%        | .515%                           | .515%                                   |  |
| Direct Cost Multiplier<br>(compounded)                                        | 1.428        | 1.065                           | 1.065                                   |  |

<sup>1</sup> Field and home office supervision and administration  
(including staff overhead costs).

<sup>2</sup> Contractor's construction equipment.

<sup>3</sup> Contractor Furnished Equipment and Material.

- Architectural - Various MTO allowances from 1 to 10 percent were used depending upon the type of material. Unit rates of installation are developed for the various architectural construction tasks from Fluor Daniel in-house information. Material pricing is developed from current in-house information.
- HVAC ductwork was estimated on a dollar per CFM basis, and prorated to the various areas of the facility on a square foot basis.
- The machinery and equipment estimate was developed from the Equipment List (Appendix II). Machinery and equipment unit rates of installation were developed from Fluor Daniel data and/or crew size and duration estimates. The installation manhours include the setting and testing of equipment. Informal pricing was developed from in-house information.
- Piping installation unit rates were developed from Fluor Daniel data, and are expressed as manhours and material dollars per LF for pipe and pipe insulation, and per EA for valves. The rates assume site shop fabrication and field erection. This includes welding, erection and bolt-up for pipe and valves. Also included are allowances for fittings, flanges, miscellaneous shoes and guides, scaffolding, 10% NDE, hydrotest and miscellaneous welding operations, plus a 10 percent MTO allowance. Piping and material pricing is developed from current in-house information.
- Electrical installation unit rates are developed from Fluor Daniel in-house data. The bulk material costs incorporated into the material installation rates are derived from in-house pricing information. The rates for conduit material and labor include assembly and installation costs. The rates include wire, assembly, installation and checkout costs. An MTO allowance of from 5 to 10 percent is included in the rates. Electrical equipment are priced from Fluor Daniel in-house information. Installation rates for electrical equipment are developed from Fluor Daniel data and/or crew size and duration estimates.
- Labor and material rates provide for installation of block and bleed valves for each control valve. Instrument rates include calibration, process connections, installation, and loop check. Instrument racks are priced to include rack piping. DCS and HP equipment is installed by the construction contractor, and checkout and testing of the equipment is provided by the vendor, which is included in the procurement cost.



### 3.1.1.2 Indirect Costs

The indirect costs of the facility are defined as the following capital costs, which are estimated to be expended during the engineering, procurement, and construction of the permanent plant facility:

- Architect/Engineer Services to provide Detail Design and Field Engineering during construction.
- Field Inspection during construction
- Construction Management services including bid package preparation, interface with contractors during construction, and storage and maintenance oversight of material and equipment (GFE) furnished to contractors as a result of advance procurement action.
- Project Management Services to provide overall project coordination, management and reporting functions.

### 3.1.1.3 Escalation

An independent escalation study provides annual escalation rates for the SNF CSB Project. The annual escalation rates were converted into compounded monthly escalation factors by the escalation study program.

Escalation is calculated for procurement, construction and indirect activities in accordance with the project schedule. Based on the schedule mid-points of the procurement, construction and indirect activities, the appropriate monthly escalation factors are applied to the package and indirect cost estimates (3rd Q GFY 1995 dollars) to arrive at escalated costs.

### 3.1.1.4 Contingency

The estimated contingency was developed from an evaluation of the completeness of design information available to estimating, and the reliability of unit cost data obtained from prior estimates. Contingency is added to the estimate to provide for risks and uncertainties associated with the scope of work at a conceptual stage in design. Contingency provides for developmental design changes, but does not fund mission changes or change orders. The following contingencies were applied to the direct procurement, construction, and indirect cost centers of the estimate:

|                       |                |
|-----------------------|----------------|
| • Cask Receiving Area | $\frac{8}{25}$ |
| • Vaults              | 15             |

|                                  |    |
|----------------------------------|----|
| • Personnel/Utility/Support Area | 25 |
| • HVAC Equipment Area            | 25 |
| • Infrastructure                 | 25 |
| • Generators                     | 25 |
| • Sample Building                | 25 |
| • Engineering                    | 15 |
| • Construction Management        | 15 |
| • Project Management             | 15 |

The composite contingency is 18 %

### 3.1.2 Basis of Material Take-Off (MTO)

The SNF CSB Project Cost Estimate is prepared from drawings, sketches, the equipment list and other documents prepared in support of the Conceptual Design Report, issued July 24, 1995

The following source material was used in the development of the direct cost estimate.

- Equipment List - Prepared by engineering, lists all major engineered equipment by system, building location, type of equipment, and tag number.
- Plot Plan - Prepared by engineering, shows the location of the CSB relative to the site. The plot plan was used to develop quantities of site excavation and backfill, to determine distances to estimate piping and electrical ductbank routed to the CSB.
- Engineering Study Sketches - Prepared by engineering, are the basis for all building concrete, steel and architectural quantities.
- Mechanical Block Flow Diagrams were used in conjunction with the Architectural Sketches to estimate piping routings.

The following percentages of direct costs were used to estimate the following indirects:

- Title III Engineering/inspection is calculated at 8% of direct costs, and split 80% to Title III Engineering, 20% to Title III inspection
- Detail Design is calculated at 20% of direct costs for new facility design and 12.5% of direct costs for existing facility design. The vault was assumed to be 80% existing design and 20% new design
- Construction Management - Estimated cost was provided by WHC for inclusion to the CDR estimate
- Project Management - Estimated cost was provided by WHC for inclusion to the CDR estimate

### 3.1.3 Estimate Format and Coding

The Conceptual Design cost estimate is organized and coded in accordance with the Project Work Breakdown Structure (PWBS) and the facility code structure by systems designation. Within the facility & system codes, CSI division codes have been assigned which are further broken down by detail codes that define each estimate line item of work. The coding structure developed for input into the ICF Kaiser Engineers Interactive Estimating System (IEST) is shown on Table 3-2.

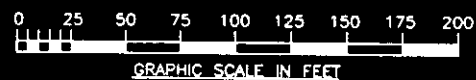
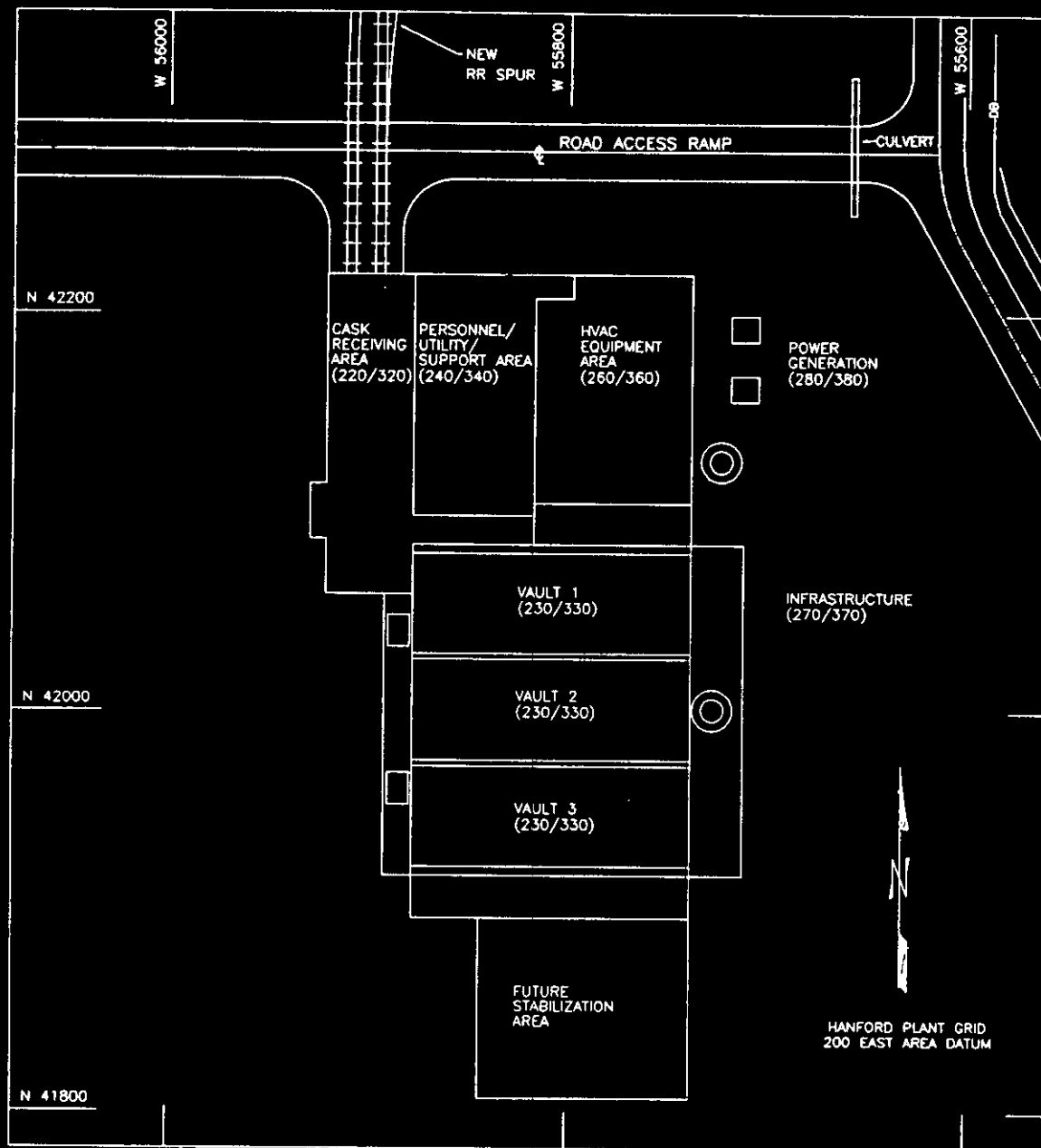
The facility estimate codes used in the estimate are shown overlaid on the Conceptual Design plot plan (Figure 3-1).

The facility estimate codes matched up to the Project Work Breakdown Structure are shown on Table 3-3.

### 3.1.4 References

The following documents were used in the preparation of the CD Estimate:

- Mechanical Block Flow Diagrams, Figures 2-33 thru 2-37, five sheets, dated July 11, 1995.
- CSB Building Plans and Sections, Figures 2-2 thru 2-8, dated July 7, 1995.
- Master Site Plan, Figure 2-1, dated July 7, 1995.
- CSB Equipment List, Appendix II, dated July 24, 1995



PREFIX 2 = PROCUREMENT  
PREFIX 3 = CONSTRUCTION

SNF CSB  
CONCEPTUAL DESIGN  
WBS AREAS

FIGURE 3-1

CAHIGIAN

7-17-95



SNF CSB Conceptual Design Report  
Westinghouse Hanford Company  
WHC P.O. TVW-SVV-370252

\*\* TEST - INTERACTIVE ESTIMATING \*\*  
SNF CANISTER STORAGE BUILDING  
CONCEPTUAL DESIGN ESTIMATE, JULY 21, 1995  
PD - PROJECT DESCRIPTIONS

Fluor Daniel, Inc.  
Government Services  
Contract 04436307

TABLE 3-3

| ESTIMATE<br>CODE | ESTIMATE CODE DESCRIPTION        | PWBS            | PWBS DESCRIPTION              |
|------------------|----------------------------------|-----------------|-------------------------------|
| 1                | ENGINEERING, DESIGN & INSPECTION |                 |                               |
| 120              | DETAILED DESIGN (TITLE II)       | 1.4.1.07.01.3.4 | TITLE II DESIGN               |
| 120000           | DETAILED DESIGN (TITLE II)       |                 |                               |
| 131              | FIELD ENGINEERING (TITLE III)    | 1.4.1.07.01.4.5 | TITLE III DESIGN & INSPECTION |
| 131000           | FIELD ENGINEERING (TITLE III)    |                 |                               |
| 132              | FIELD INSPECTION                 | 1.4.1.07.01.4.5 | TITLE III DESIGN & INSPECTION |
| 132000           | FIELD INSPECTION                 |                 |                               |
| 2                | PROCUREMENT                      | 1.4.1.07.01.4.2 | PROCUREMENT                   |
| 220              | CASK RECEIVING AREA              |                 |                               |
| 220050           | HVAC                             |                 |                               |
| 220210           | MCO SERVICE STATIONS             |                 |                               |
| 220720           | COLD HANDLING EQUIPMENT          |                 |                               |
| 230              | VAULTS 1, 2 & 3                  |                 |                               |
| 230720           | COLD HANDLING EQUIPMENT          |                 |                               |
| 240              | PERSONNEL/UTILITY/SUPPORT AREA   |                 |                               |
| 240050           | HVAC                             |                 |                               |
| 240320           | ELECTRICAL DISTRIBUTION          |                 |                               |
| 240410           | INSTRUMENT AIR                   |                 |                               |
| 240480           | PROCESS WATER SYSTEM             |                 |                               |
| 240530           | LIQUID WASTE COLLECTION SYSTEM   |                 |                               |
| 240610           | DCS                              |                 |                               |
| 240620           | HEALTH PHYSICS SYSTEM            |                 |                               |
| 240720           | COLD HANDLING EQUIPMENT          |                 |                               |
| 260              | HVAC EQUIPMENT AREA              |                 |                               |
| 260050           | HVAC                             |                 |                               |

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\*\* TEST - INTERACTIVE ESTIMATING \*\*  
SNF CANISTER STORAGE BUILDING  
CONCEPTUAL DESIGN ESTIMATE, JULY 21, 1995  
PD - PROJECT DESCRIPTIONS

Fluor Daniel, Inc.  
Government Services  
Contract 04436307

TABLE 3-3

| ESTIMATE<br>CODE | ESTIMATE CODE DESCRIPTION      | PUBS            | PUBS DESCRIPTION              |
|------------------|--------------------------------|-----------------|-------------------------------|
| 270              | INFRASTRUCTURE                 |                 |                               |
| 270520           | DRAIN LINES                    |                 |                               |
| 280              | POWER GENERATION               |                 |                               |
| 280320           | ELECTRICAL DISTRIBUTION        |                 |                               |
| 3                | CONSTRUCTION                   | 1.4.1.07.01.4.7 | CM CONSTRUCTION/FP CONTRACTOR |
| 320              | CASK RECEIVING AREA            |                 |                               |
| 320010           | STRUCTURES                     |                 |                               |
| 320040           | FIRE PROTECTION                |                 |                               |
| 320050           | HVAC                           |                 |                               |
| 320210           | MCO SERVICE STATIONS           |                 |                               |
| 320320           | ELECTRICAL DISTRIBUTION        |                 |                               |
| 320650           | COMMUNICATIONS                 |                 |                               |
| 320720           | COLD HANDLING EQUIPMENT        |                 |                               |
| 330              | VAULTS 1, 2 & 3                |                 |                               |
| 330010           | STRUCTURES                     |                 |                               |
| 330040           | FIRE PROTECTION                |                 |                               |
| 330050           | HVAC                           |                 |                               |
| 330320           | ELECTRICAL DISTRIBUTION        |                 |                               |
| 330650           | COMMUNICATIONS                 |                 |                               |
| 330720           | COLD HANDLING EQUIPMENT        |                 |                               |
| 340              | PERSONNEL/UTILITY/SUPPORT AREA |                 |                               |
| 340010           | STRUCTURES                     |                 |                               |
| 340040           | FIRE PROTECTION                |                 |                               |
| 340050           | HVAC                           |                 |                               |
| 340320           | ELECTRICAL DISTRIBUTION        |                 |                               |
| 340410           | INSTRUMENT AIR                 |                 |                               |
| 340480           | PROCESS WATER SYSTEM           |                 |                               |
| 340490           | SANITARY WATER SYSTEM          |                 |                               |
| 340530           | LIQUID WASTE COLLECTION SYSTEM |                 |                               |
| 340610           | DCS                            |                 |                               |
| 340620           | HEALTH PHYSICS SYSTEM          |                 |                               |
| 340650           | COMMUNICATIONS                 |                 |                               |
| 340720           | COLD HANDLING EQUIPMENT        |                 |                               |
| 360              | HVAC EQUIPMENT AREA            |                 |                               |

SNF CSB Conceptual Design Report  
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\*\* TEST - INTERACTIVE ESTIMATING \*\*  
SNF CANISTER STORAGE BUILDING  
CONCEPTUAL DESIGN ESTIMATE, JULY 21, 1995  
PD - PROJECT DESCRIPTIONS

Fluor Daniel, Inc.  
Government Services  
Contract 04436307

TABLE 3-3

| ESTIMATE<br>CODE | ESTIMATE CODE DESCRIPTION       | PWBS            | PWBS DESCRIPTION        |
|------------------|---------------------------------|-----------------|-------------------------|
| 360010           | STRUCTURES                      |                 |                         |
| 360040           | FIRE PROTECTION                 |                 |                         |
| 360050           | HVAC                            |                 |                         |
| 360320           | ELECTRICAL DISTRIBUTION         |                 |                         |
| 360650           | COMMUNICATIONS                  |                 |                         |
| 370              | INFRASTRUCTURE                  |                 |                         |
| 370010           | SITE WORK                       |                 |                         |
| 370320           | ELECTRICAL DISTRIBUTION         |                 |                         |
| 370490           | SANITARY WATER SYSTEM           |                 |                         |
| 370500           | FIRE WATER SYSTEM               |                 |                         |
| 370510           | SANITARY SEWER SYSTEM           |                 |                         |
| 370520           | DRAIN LINES                     |                 |                         |
| 380              | POWER GENERATION                |                 |                         |
| 380010           | STRUCTURES                      |                 |                         |
| 380040           | FIRE PROTECTION                 |                 |                         |
| 380320           | ELECTRICAL DISTRIBUTION         |                 |                         |
| 380650           | COMMUNICATIONS                  |                 |                         |
| 385              | SAMPLING BUILDING               |                 |                         |
| 385010           | STRUCTURES                      |                 |                         |
| 385040           | FIRE PROTECTION                 |                 |                         |
| 385320           | ELECTRICAL DISTRIBUTION         |                 |                         |
| 385630           | SAMPLING SYSTEM                 |                 |                         |
| 390              | CONSTRUCTION PRORATES           |                 |                         |
| 390995           | MOBILIZATION/DEMobilIZATION     |                 |                         |
| 390999           | CONSTRUCTION ACCEPTANCE TESTING |                 |                         |
| 4                | CONSTRUCTION MANAGEMENT         | 1.4.1.07.01.4.1 | CONSTRUCTION MANAGEMENT |
| 411              | CONSTRUCTION MANAGEMENT         |                 |                         |
| 5                | PROJECT MANAGEMENT              |                 |                         |
| 511              | PROJECT MANAGEMENT              | 1.4.1.07.01.2   | PROJECT MANAGEMENT      |



The following documents were used as reference during the preparation of the estimate:

- Hanford Waste Vittrification Plant (HWVP) Baseline Preliminary Design Estimate, Rev. "F", dated July 1991.
- K-D 3B ICE estimate of Package 350 HWVP Canister Storage Building (CSB) dated October, 1992.
- Staging and Storage Facility Feasibility Study, Final Report, dated February, 1995.
- Canister Storage Building Trade Study, Final Report, dated May, 1995.

### 3.2 ESTIMATE SUMMARIES

The following estimate summaries are presented in this section:

- Total estimated cost by DOE code, Table 3-4
- Total estimated cost by PWBS, Table 3-5
- Total estimated cost by facility code, Table 3-6
- Direct cost summary by facility code, Table 3-7
- Direct cost summary by CSI, Table 3-8

SNF CSB CONCEPTUAL DESIGN REPORT  
WESTINGHOUSE HANFORD COMPANY  
WHC P.O. TVU-SVV-370252

\*\* TEST - INTERACTIVE ESTIMATING \*\*  
SNF CANISTER STORAGE BUILDING  
CONCEPTUAL DESIGN ESTIMATE, JULY 21, 1995  
DOE\_R01 - PROJECT COST SUMMARY BY DOE CODE

FLUOR DANIEL, INC.  
GOVERNMENT SERVICES  
DATE 07/21/95 12:00:01  
BY JFD/AAF/RLJ

TABLE 3-4

| COST<br>CODE | DESCRIPTION                       | 1995 \$<br>TOTAL COST | ESCALATED<br>TOTAL COST | CONTINGENCY<br>% | CONTINGENCY<br>TOTAL | TOTAL<br>ESTIMATED<br>COST |
|--------------|-----------------------------------|-----------------------|-------------------------|------------------|----------------------|----------------------------|
| 000          | ENGINEERING                       | 13,480,000            | 13,830,000              | 15               | 2,070,000            | 15,900,000                 |
| 460          | IMPROVEMENTS TO LAND              | 1,680,000             | 1,760,000               | 25               | 440,000              | 2,200,000                  |
| 501          | BUILDINGS                         | 38,040,000            | 39,900,000              | 17               | 6,880,000            | 46,780,000                 |
| 600          | UTILITIES                         | 610,000               | 640,000                 | 25               | 160,000              | 800,000                    |
| 700          | SPECIAL EQUIPMENT/PROCESS SYSTEMS | 15,550,000            | 16,150,000              | 23               | 3,730,000            | 19,880,000                 |
| 720          | LABORATORY EQUIPMENT              | 10,000                | 10,000                  | 25               | 0                    | 10,000                     |
| 755          | SHOP EQUIPMENT                    | 60,000                | 60,000                  | 25               | 20,000               | 80,000                     |
| XXX          | CONSTRUCTION MANAGEMENT           | 4,040,000             | 4,240,000               | 15               | 640,000              | 4,880,000                  |
| YYY          | PROJECT MANAGEMENT                | 3,800,000             | 3,970,000               | 15               | 590,000              | 4,560,000                  |
|              | TOTAL CAPITAL COST                | 77,270,000            | 80,560,000              | 18               | 14,530,000           | 95,090,000                 |

REMARKS:

THE CONCEPTUAL DESIGN ESTIMATE REFLECTS THE CONSTRUCTION OF THREE STORAGE VAULTS, WITH THE INSTALLATION OF 440 STANDARD, AND 11 OVERPACK CARBON STEEL STORAGE TUBES IN TWO VAULTS.

(ROUNDED/ADJUSTED TO THE NEAREST " 10,000 / 100,000 " - PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING)

SNF CSB CONCEPTUAL DESIGN REPORT  
WESTINGHOUSE HANFORD COMPANY  
WHC P.O. TVW-SVV-370252

\*\* TEST - INTERACTIVE ESTIMATING \*\*  
SNF CANISTER STORAGE BUILDING  
CONCEPTUAL DESIGN ESTIMATE, JULY 21, 1995  
DOE\_R01 - PROJECT COST SUMMARY BY PUBS

FLUOR DANIEL, INC.  
GOVERNMENT SERVICES  
DATE 07/21/95 12:00:01  
BY JFD/AAF/RLJ

TABLE 3-5

| PROJECT WORK<br>BREAKDOWN<br>STRUCTURE | DESCRIPTION               | 1995 \$<br>TOTAL COST | ESCALATED<br>TOTAL COST | CONTINGENCY<br>X | CONTINGENCY<br>TOTAL | TOTAL<br>ESTIMATED<br>COST |
|----------------------------------------|---------------------------|-----------------------|-------------------------|------------------|----------------------|----------------------------|
| 1.4.1.07.01.2                          | PROJECT MANAGEMENT        | 2,810,000             | 2,940,000               | 15               | 430,000              | 3,370,000                  |
| 1.4.1.07.01.3                          | DESIGN                    | 9,000,000             | 9,150,000               | 15               | 1,380,000            | 10,530,000                 |
| 1.4.1.07.01.4                          | CONSTRUCTION              | 64,470,000            | 67,440,000              | 19               | 12,560,000           | 80,000,000                 |
| 1.4.1.07.01.7                          | REGULATORY COMPLIANCE     | 990,000               | 1,030,000               | 15               | 160,000              | 1,190,000                  |
| 1.4.1.07.01                            | CANISTER STORAGE BUILDING | 72,270,000            | 80,560,000              | 18               | 14,530,000           | 95,090,000                 |

NOTE:

PUBS 1.4.07.01.3 DESIGN = TITLE II (DETAILED DESIGN) ONLY.  
PUBS 1.4.07.01.4 CONSTRUCTION = TITLE III DESIGN/INSPECTION,  
PROCUREMENT, CONSTRUCTION,  
AND CONSTRUCTION MANAGEMENT.

(ROUNDED/ADJUSTED TO THE NEAREST = 10,000 / 100,000 " - PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING)

SNF CSB CONCEPTUAL DESIGN REPORT  
WESTINGHOUSE HANFORD COMPANY  
WMC P.O. TVM-SVV-370252

\*\* TEST - INTERACTIVE ESTIMATING \*\*  
SNF CAMISTER STORAGE BUILDING  
CONCEPTUAL DESIGN ESTIMATE, JULY 21, 1995  
DOE\_R02 - PROJECT COST SUMMARY BY FACILITY CODE

FLUOR DANIEL, INC.,  
GOVERNMENT SERVICES  
DATE 07/21/95 12:00:01  
BY JFD/AAF/RLJ

TABLE 3-6

| WBS           | DESCRIPTION                    | ESTIMATE<br>SUBTOTAL | ONSITE<br>INDIRECTS | SUB<br>TOTAL | ESCALATION<br>% | ESCALATION<br>TOTAL | ESCALATED<br>TOTAL COST | CONTINGENCY<br>% | CONTINGENCY<br>TOTAL | TOTAL<br>ESTIMATED<br>COST |
|---------------|--------------------------------|----------------------|---------------------|--------------|-----------------|---------------------|-------------------------|------------------|----------------------|----------------------------|
| 120           | DETAILED DESIGN (TITLE II)     | 9000000              | 0                   | 9000000      | 1.74            | 156600              | 9156600                 | 15               | 1373490              | 10530090                   |
| 131           | FIELD ENGINEERING (TITLE III)  | 3580000              | 0                   | 3580000      | 4.39            | 157162              | 3737162                 | 15               | 560574               | 4297736                    |
| 132           | FIELD INSPECTION               | 900000               | 0                   | 900000       | 4.39            | 39510               | 939510                  | 15               | 140927               | 1080437                    |
| SUBTOTAL 1    | ENGINEERING, DESIGN & INSPE    | 13480000             | 0                   | 13480000     | 2.62            | 353272              | 13833272                | 15               | 2074991              | 15908263                   |
| 220           | CASK RECEIVING AREA            | 3143992              | 0                   | 3143992      | 3.50            | 110040              | 3254032                 | 25               | 813508               | 4067539                    |
| 230           | VAULTS 1, 2 & 3                | 2452278              | 0                   | 2452278      | 3.50            | 85829               | 2538107                 | 15               | 380716               | 2918824                    |
| 240           | PERSONNEL/UTILITY/SUPPORT AREA | 5015577              | 0                   | 5015577      | 3.50            | 175545              | 5191122                 | 25               | 1297779              | 6488902                    |
| 260           | HVAC EQUIPMENT AREA            | 986192               | 0                   | 986192       | 3.50            | 34517               | 1020709                 | 25               | 255177               | 1275886                    |
| 270           | INFRASTRUCTURE                 | 11251                | 0                   | 11251        | 3.50            | 394                 | 11645                   | 25               | 2911                 | 14556                      |
| 280           | POWER GENERATION               | 121695               | 0                   | 121695       | 3.50            | 4259                | 125954                  | 25               | 31489                | 157443                     |
| SUBTOTAL 2    | PROCUREMENT                    | 11730985             | 0                   | 11730985     | 3.50            | 410584              | 12141569                | 23               | 2781580              | 14923150                   |
| 320           | CASK RECEIVING AREA            | 6470511              | 0                   | 6470511      | 4.89            | 316408              | 6786919                 | 25               | 1696730              | 8483649                    |
| 330           | VAULTS 1, 2 & 3                | 30058774             | 0                   | 30058774     | 4.89            | 1469872             | 31528646                | 15               | 4729296              | 36257943                   |
| 340           | PERSONNEL/UTILITY/SUPPORT AREA | 2151699              | 0                   | 2151699      | 4.89            | 105219              | 2256918                 | 25               | 564227               | 2821146                    |
| 360           | HVAC EQUIPMENT AREA            | 1791228              | 0                   | 1791228      | 4.89            | 87591               | 1878819                 | 25               | 469705               | 2348524                    |
| 370           | INFRASTRUCTURE                 | 1677947              | 0                   | 1677947      | 4.89            | 82052               | 1759999                 | 25               | 439999               | 2199998                    |
| 380           | POWER GENERATION               | 281943               | 0                   | 281943       | 4.89            | 13787               | 295730                  | 25               | 73934                | 369664                     |
| 385           | SAMPLING BUILDING              | 31174                | 0                   | 31174        | 4.89            | 1525                | 32699                   | 25               | 8174                 | 40873                      |
| 390           | CONSTRUCTION PRORATES          | 1754269              | 0                   | 1754269      | 4.89            | 85784               | 1840053                 | 25               | 460013               | 2300066                    |
| SUBTOTAL 3    | CONSTRUCTION                   | 44217545             | 0                   | 44217545     | 4.89            | 2162238             | 46379783                | 18               | 8442078              | 54821863                   |
| 411           | CONSTRUCTION MANAGEMENT        | 4040000              | 0                   | 4040000      | 4.89            | 197556              | 4237556                 | 15               | 635633               | 4873189                    |
| SUBTOTAL 4    | CONSTRUCTION MANAGEMENT        | 4040000              | 0                   | 4040000      | 4.89            | 197556              | 4237556                 | 15               | 635633               | 4873189                    |
| 511           | PROJECT MANAGEMENT             | 3800000              | 0                   | 3800000      | 4.39            | 166820              | 3966820                 | 15               | 595023               | 4561843                    |
| SUBTOTAL 5    | PROJECT MANAGEMENT             | 3800000              | 0                   | 3800000      | 4.39            | 166820              | 3966820                 | 15               | 595023               | 4561843                    |
| PROJECT TOTAL |                                | 77,268,530           | 0                   | 77,268,530   | 4.26            | 3,290,470           | 80,559,000              | 18               | 16,529,305           | 95,088,308                 |

SNF CSB CONCEPTUAL DESIGN REPORT  
WESTINGHOUSE HANFORD COMPANY  
WHC P.O. TVH-SVV-370252

\*\* TEST - INTERACTIVE ESTIMATING \*\*  
SNF CANISTER STORAGE BUILDING  
CONCEPTUAL DESIGN ESTIMATE, JULY 21, 1995  
\$1 - DIRECT COST SUMMARY BY FACILITY CODE

FLUOR DANIEL, INC.  
GOVERNMENT SERVICES  
DATE 07/21/95 12:00:01  
BY JFD/AAF/RLJ

TABLE 3-7

| WBS           | DESCRIPTION                    | MANHOURS | LABOR      | EQUIP<br>USAGE | MATERIAL   | SUB-<br>CONTRACT | EQUIPMENT  | OVERHEAD<br>& PROFIT | TOTAL<br>DIRECT<br>DOLLARS |
|---------------|--------------------------------|----------|------------|----------------|------------|------------------|------------|----------------------|----------------------------|
| 120           | DETAILED DESIGN (TITLE II)     | 0        | 0          | 0              | 0          | 9000000          | 0          | 0                    | 9000000                    |
| 131           | FIELD ENGINEERING (TITLE III)  | 0        | 0          | 0              | 0          | 3580000          | 0          | 0                    | 3580000                    |
| 132           | FIELD INSPECTION               | 0        | 0          | 0              | 0          | 900000           | 0          | 0                    | 900000                     |
| SUBTOTAL 1    | ENGINEERING, DESIGN & INSPE    | 0        | 0          | 0              | 0          | 13480000         | 0          | 0                    | 13480000                   |
| 220           | CASK RECEIVING AREA            | 0        | 0          | 0              | 0          | 0                | 2952103    | 191889               | 3143992                    |
| 230           | VAULTS 1, 2 & 3                | 0        | 0          | 0              | 0          | 0                | 2302608    | 149670               | 2452278                    |
| 240           | PERSONNEL/UTILITY/SUPPORT AREA | 0        | 0          | 0              | 0          | 0                | 4709459    | 306118               | 5015577                    |
| 260           | HVAC EQUIPMENT AREA            | 0        | 0          | 0              | 0          | 0                | 926002     | 60190                | 986192                     |
| 270           | INFRASTRUCTURE                 | 0        | 0          | 0              | 0          | 0                | 10564      | 687                  | 11251                      |
| 280           | POWER GENERATION               | 0        | 0          | 0              | 0          | 0                | 114268     | 7427                 | 121695                     |
| SUBTOTAL 2    | PROCUREMENT                    | 0        | 0          | 0              | 0          | 0                | 11015004   | 715981               | 11730985                   |
| 320           | CASK RECEIVING AREA            | 103448   | 3074281    | 318959         | 1634506    | 0                | 0          | 1442765              | 6470511                    |
| 330           | VAULTS 1, 2 & 3                | 378902   | 11368942   | 1297361        | 11574396   | 105000           | 0          | 5713075              | 30058774                   |
| 340           | PERSONNEL/UTILITY/SUPPORT AREA | 28731    | 920716     | 104563         | 681268     | 0                | 0          | 445152               | 2151699                    |
| 360           | HVAC EQUIPMENT AREA            | 23715    | 724139     | 98611          | 612334     | 0                | 0          | 356144               | 1791228                    |
| 370           | INFRASTRUCTURE                 | 22721    | 668870     | 180364         | 498323     | 0                | 0          | 330390               | 1677947                    |
| 380           | POWER GENERATION               | 3662     | 116349     | 11065          | 97666      | 0                | 0          | 56863                | 281943                     |
| 385           | SAMPLING BUILDING              | 289      | 10088      | 820            | 14925      | 0                | 0          | 5341                 | 31174                      |
| 390           | CONSTRUCTION PRORATES          | 44917    | 1228480    | 0              | 0          | 0                | 0          | 525769               | 1754269                    |
| SUBTOTAL 3    | CONSTRUCTION                   | 606385   | 18111865   | 2011743        | 15113418   | 105000           | 0          | 8875519              | 44217545                   |
| 411           | CONSTRUCTION MANAGEMENT        | 0        | 0          | 0              | 0          | 4040000          | 0          | 0                    | 4040000                    |
| SUBTOTAL 4    | CONSTRUCTION MANAGEMENT        | 0        | 0          | 0              | 0          | 4040000          | 0          | 0                    | 4040000                    |
| 511           | PROJECT MANAGEMENT             | 0        | 0          | 0              | 0          | 3800000          | 0          | 0                    | 3800000                    |
| SUBTOTAL 5    | PROJECT MANAGEMENT             | 0        | 0          | 0              | 0          | 3800000          | 0          | 0                    | 3800000                    |
| PROJECT TOTAL |                                | 606,385  | 18,111,865 | 2,011,743      | 15,113,418 | 21,425,000       | 11,015,004 | 9,591,500            | 77,268,530                 |

SNF CSB CONCEPTUAL DESIGN REPORT  
WESTINGHOUSE HANFORD COMPANY  
WHC P.O. TVM-SVV-370252

\*\* TEST - INTERACTIVE ESTIMATING \*\*  
SNF CANISTER STORAGE BUILDING  
CONCEPTUAL DESIGN ESTIMATE, JULY 21, 1995  
2 - DIRECT COST SUMMARY BY CSI CODE OF ACCOUNTS

FLUOR DANIEL, INC.  
GOVERNMENT SERVICES  
DATE 07/21/95 12:00:01  
BY JPD/AAF/RLJ

TABLE 3-8

| CSI | DESCRIPTION                       | MANHOURS | LABOR    | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIPMENT | OVERHEAD<br>& PROFIT | TOTAL<br>DIRECT<br>DOLLARS |
|-----|-----------------------------------|----------|----------|----------------|----------|------------------|-----------|----------------------|----------------------------|
| 01  | GENERAL REQUIRMENTS               | 33613    | 924403   | 40390          | 308596   | 0                | 0         | 418327               | 1691716                    |
| 02  | SITEMWORK                         | 13874    | 395459   | 167316         | 39110    | 0                | 0         | 182673               | 784558                     |
| 03  | CONCRETE                          | 364676   | 10783473 | 926287         | 3979889  | 105000           | 0         | 4944730              | 20739379                   |
| 05  | METALS                            | 72451    | 2314473  | 607898         | 8650109  | 0                | 0         | 1592366              | 13164846                   |
| 07  | MOISTURE AND THERMAL              | 6373     | 192255   | 12046          | 377391   | 0                | 0         | 107598               | 689290                     |
| 08  | DOORS, WINDOWS AND G              | 711      | 21587    | 1729           | 76527    | 0                | 0         | 14327                | 114170                     |
| 09  | FINISHES                          | 37243    | 994169   | 44889          | 516653   | 0                | 0         | 462002               | 2017713                    |
| 11  | EQUIPMENT                         | 2720     | 89312    | 24610          | 6468     | 0                | 987879    | 104460               | 1212729                    |
| 13  | SPECIAL CONSTRUCTION              | 2765     | 85374    | 11480          | 5718     | 0                | 855824    | 93289                | 1051685                    |
| 14  | CONVEYING SYSTEMS                 | 1880     | 59333    | 17554          | 0        | 0                | 3740660   | 269678               | 4087225                    |
| 15  | MECHANICAL                        | 18215    | 602726   | 60584          | 280664   | 0                | 936890    | 341049               | 2221913                    |
| 16  | ELECTRICAL                        | 26980    | 909420   | 60723          | 686877   | 0                | 316501    | 458402               | 2431923                    |
| 17  | INSTRUMENTATION                   | 8040     | 279198   | 36237          | 185416   | 0                | 4177250   | 405427               | 5083528                    |
| 19  | CONST ACCPTANCE TESTING           | 16844    | 460683   | 0              | 0        | 0                | 0         | 197172               | 657855                     |
| 91  | ENGINEERING, DESIGN, & INSPECTION | 0        | 0        | 0              | 0        | 13480000         | 0         | 0                    | 13480000                   |
| 92  | GENERAL CONTRACTOR                | 0        | 0        | 0              | 0        | 4040000          | 0         | 0                    | 4040000                    |
| 93  | PROJECT MANAGEMENT                | 0        | 0        | 0              | 0        | 3800000          | 0         | 0                    | 3800000                    |

PROJECT TOTAL

606,385 18,111,865 2,011,743 15,113,418 21,425,000 9,591,500 77,268,530

### 3.3 ESTIMATE DETAIL

The attached SNF CSB estimate detail presented in this section is sorted by facility code/system/CSI code of accounts.



FLUOR DANIEL INC.  
WESTINGHOUSE HANFORD COMPANY  
JOB NO. 04436307

\*\* IEST - INTERACTIVE ESTIMATING \*\*  
SNF CANISTER STORAGE BUILDING  
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| ACCOUNT<br>NUMBER | DESCRIPTION                                   | COST<br>CODE | QUANTITY | MANHOURS | LABOR | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OR&P<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|-----------------------------------------------|--------------|----------|----------|-------|----------------|----------|------------------|----------------|-----------------|------------------|
| 120000            | DETAILED DESIGN (TITLE II)                    |              |          |          |       |                |          |                  |                |                 |                  |
| 120000.9120001    | DETAILED DESIGN (TITLE II)                    | 000          | 1 LOT    | 0        | 0     | 0              | 0        | 9000000          | 0              | 0               | 9000000          |
| SUBTOTAL 120000   | DETAILED DESIGN (TITLE II)                    |              |          | 0        | 0     | 0              | 0        | 9,000,000        | 0              | 0               | 9,000,000        |
| SUBTOTAL 120      | DETAILED DESIGN (TITLE II)                    |              |          | 0        | 0     | 0              | 0        | 9,000,000        | 0              | 0               | 9,000,000        |
| 131000            | FIELD ENGINEERING (TITLE III)                 |              |          |          |       |                |          |                  |                |                 |                  |
| 131000.9130001    | FIELD ENGINEERING (TITLE III)                 | 000          | 1 LOT    | 0        | 0     | 0              | 0        | 3580000          | 0              | 0               | 3580000          |
| SUBTOTAL 131000   | FIELD ENGINEERING (TITLE II)                  |              |          | 0        | 0     | 0              | 0        | 3,580,000        | 0              | 0               | 3,580,000        |
| SUBTOTAL 131      | FIELD ENGINEERING (TITLE II)                  |              |          | 0        | 0     | 0              | 0        | 3,580,000        | 0              | 0               | 3,580,000        |
| 132000            | FIELD INSPECTION                              |              |          |          |       |                |          |                  |                |                 |                  |
| 132030.9150001    | FIELD INSPECTION                              | 000          | 1 LOT    | 0        | 0     | 0              | 0        | 900000           | 0              | 0               | 900000           |
| SUBTOTAL 132000   | FIELD INSPECTION                              |              |          | 0        | 0     | 0              | 0        | 900,000          | 0              | 0               | 900,000          |
| SUBTOTAL 132      | FIELD INSPECTION                              |              |          | 0        | 0     | 0              | 0        | 900,000          | 0              | 0               | 900,000          |
| SUBTOTAL 1        | ENGINEERING, DESIGN & INSPE                   |              |          | 0        | 0     | 0              | 0        | 13,480,000       | 0              | 0               | 13,480,000       |
| 220050            | HVAC                                          |              |          |          |       |                |          |                  |                |                 |                  |
| 220050.1544AAB    | EH-1 THRU 4<br>ELECTRIC UNIT HEATERS<br>10 KV | 700          | 4 EA     | 0        | 0     | 0              | 0        | 0                | 3234           | 210             | 3444             |
| 220050.1549AAA    | RV-1 THRU 4<br>POWER ROOF VENTILATORS         | 501          | 4 EA     | 0        | 0     | 0              | 0        | 0                | 2587           | 168             | 2755             |

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WHC-SD-W379-CDR-001 Rev. 0

FLUOR DANIEL INC.  
WESTINGHOUSE HANFORD COMPANY  
JOB NO. 04436307

\*\* TEST - INTERACTIVE ESTIMATING \*\*  
SNF CANISTER STORAGE BUILDING  
CONCEPTUAL DESIGN ESTIMATE, JULY 21, 1995  
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| ACCOUNT<br>NUMBER | DESCRIPTION                           | COST<br>CODE | QUANTITY | MANHOURS | LABOR | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OH&P<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|---------------------------------------|--------------|----------|----------|-------|----------------|----------|------------------|----------------|-----------------|------------------|
|                   | 4000 CFM<br>2 HP                      |              |          |          |       |                |          |                  |                |                 |                  |
|                   | SUBTOTAL 220050 HVAC                  |              |          | 0        | 0     | 0              | 0        | 0                | 5,821          | 378             | 6,199            |
| 220210            | MCO SERVICE STATIONS                  |              |          |          |       |                |          |                  |                |                 |                  |
| 220210.1167AAA    | SR-1                                  | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 1078           | 70              | 1148             |
|                   | M2 CYLINDER RACK<br>(CS)              |              |          |          |       |                |          |                  |                |                 |                  |
|                   | SUBTOTAL 220210 MCO SERVICE STATIONS  |              |          | 0        | 0     | 0              | 0        | 0                | 1,078          | 70              | 1,148            |
| 220720            | COLD HANDLING EQUIPMENT               |              |          |          |       |                |          |                  |                |                 |                  |
| 220720.1167AAB    | SR-2                                  | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 21883          | 1423            | 23306            |
|                   | STORAGE RACK<br>28/1/2<br>(304LSS)    |              |          |          |       |                |          |                  |                |                 |                  |
| 220720.1167AAQ    | SS-1                                  | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 43120          | 2803            | 45923            |
| 220720.1167AAR    | MCO SERVICE STATION<br>TV-1A/B/C      | 700          | 3 EA     | 0        | 0     | 0              | 0        | 0                | 67267          | 4372            | 71639            |
| 220720.1167AAT    | CCTV                                  | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 19404          | 1261            | 20665            |
|                   | HA-4                                  |              |          |          |       |                |          |                  |                |                 |                  |
|                   | HATCH CASK ENTRANCE<br>60" DIA        |              |          |          |       |                |          |                  |                |                 |                  |
|                   | (CS)                                  |              |          |          |       |                |          |                  |                |                 |                  |
| 220720.1167AAU    | SA-1                                  | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 80850          | 5255            | 86105            |
| 220720.1167AAV    | CASK, INTERNAL SAMPLING EQUIP<br>HD-1 | 700          | 1 LOT    | 0        | 0     | 0              | 0        | 0                | 5390           | 350             | 5740             |
| 220720.1167AAX    | LANCES<br>HD-3                        | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 21560          | 1401            | 22961            |
| 220720.1167AAY    | GRAPPLE<br>VR-1                       | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 21560          | 1401            | 22961            |
| 220720.1167AAZ    | WASH RACK<br>HD-4                     | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 3773           | 246             | 4019             |
| 220720.1167ABA    | YOKE, TRANSPORT CASK<br>HD-6          | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 16170          | 1051            | 17221            |
| 220720.1167ABD    | MCO HANDLING DEVICE(EMPTY)<br>HD-8    | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 26950          | 1752            | 28702            |
| 220720.1335AAA    | RAILCAR MOVING DEVICE<br>SD-1A/B      | 700          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 204820         | 13313           | 218133           |
|                   | SHIELD DOOR                           |              |          |          |       |                |          |                  |                |                 |                  |

FLUR DANIEL INC.  
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| ACCOUNT<br>NUMBER | DESCRIPTION                                                                       | COST<br>CODE | QUANTITY | MANHOURS | LABOR | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OH&P<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|-----------------------------------------------------------------------------------|--------------|----------|----------|-------|----------------|----------|------------------|----------------|-----------------|------------------|
| 220720.1335AAB    | 5"X12"X20'<br>(CS)<br>SZ-1C THRU G<br>SHIELD WINDOWS W/WALL LINER<br>& FRAME      | 700          | 5 EA     | 0        | 0     | 0              | 0        | 0                | 165473         | 10756           | 176229           |
| 220720.1335AAC    | SD-2A/B<br>SHIELD DOOR<br>4"X12"X20'<br>(CS)                                      | 700          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 172480         | 11211           | 183691           |
| 220720.1335AAD    | SD-3<br>SHIELD DOOR<br>4"X6"X20'<br>(CS)                                          | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 118580         | 7708            | 126288           |
| 220720.1335AAE    | SZ-1A/B<br>SHIELD WINDOWS W/WALL LINER<br>& FRAME                                 | 700          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 66189          | 4302            | 70491            |
| 220720.1335AAF    | SD-8<br>SHIELD DOOR, TUNNEL<br>(4"X3'X7')                                         | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 9163           | 596             | 9759             |
| 220720.1335AAG    | SD-4A<br>SHIELD DOOR, PERSONNEL<br>(5"X3'X7')                                     | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 10780          | 701             | 11481            |
| 220720.1335AAH    | SD-4B<br>SHIELD DOOR, PERSONNEL<br>(5"X3'X7')                                     | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 10780          | 701             | 11481            |
| 220720.1335AAJ    | SD-6A/B<br>SHIELD DOOR, PERSONNEL<br>(4"X3'X7')                                   | 700          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 18326          | 1191            | 19517            |
| 220720.1335AAK    | SD-6C<br>SHIELD DOOR, PERSONNEL<br>(4"X3'X7')                                     | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 9163           | 596             | 9759             |
| 220720.1335AAL    | SD-7<br>SHIELD DOOR, PERSONNEL<br>(4"X6'X7')                                      | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 16170          | 1051            | 17221            |
| 220720.1335AAM    | SD-9<br>SHIELD DOOR, TUNNEL<br>(8"X3'X7')                                         | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 15092          | 981             | 16073            |
| 220720.1648AAA    | CN-1<br>BRIDGE CRANE, TRANSPORT CASK<br>60 TON MAIN W/10 TON AUX<br>40' SPAN (CS) | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 1078000        | 70070           | 1148070          |
| 220720.1648AAC    | CN-3<br>JIB CRANE, CASK LOADING PIT                                               | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 80850          | 5255            | 86105            |

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| ACCOUNT<br>NUMBER                       | DESCRIPTION                                                                      | COST<br>CODE | QUANTITY | MANHOURS | LABOR | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OH&P<br>/ B & I | TOTAL<br>DOLLARS |
|-----------------------------------------|----------------------------------------------------------------------------------|--------------|----------|----------|-------|----------------|----------|------------------|----------------|-----------------|------------------|
| -----                                   |                                                                                  |              |          |          |       |                |          |                  |                |                 |                  |
| 220720.1448AAE                          | 10 TON W/6' BOOM<br>(CS)<br>CN-5A/B<br>CART TRANSFER CASK<br>30 TON<br>(SS & CS) | 700          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 291060         | 18919           | 309979           |
| 220720.1448AAF                          | CN-6<br>CRANE UNDER HUNG<br>5 TON, 36' SPAN                                      | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 350350         | 22773           | 373123           |
| -----                                   |                                                                                  |              |          |          |       |                |          |                  |                |                 |                  |
| SUBTOTAL 220720 COLD HANDLING EQUIPMENT |                                                                                  |              |          | 0        | 0     | 0              | 0        | 0                | 2,945,203      | 191,439         | 3,136,642        |
| -----                                   |                                                                                  |              |          |          |       |                |          |                  |                |                 |                  |
| SUBTOTAL 220 CASK RECEIVING AREA        |                                                                                  |              |          | 0        | 0     | 0              | 0        | 0                | 2,952,102      | 191,887         | 3,143,989        |
| -----                                   |                                                                                  |              |          |          |       |                |          |                  |                |                 |                  |
| 230720                                  | COLD HANDLING EQUIPMENT                                                          | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 80850          | 5255            | 86105            |
| 230720.1147AAN                          | CK-2<br>FLASK, FLOOR PLUG<br>(CS)                                                | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 161700         | 10511           | 172211           |
| 230720.1147AAO                          | NA-1<br>GATE PORTABLE SHIELDING<br>(CS)                                          | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 98098          | 6376            | 104474           |
| 230720.1147AAP                          | NA-2<br>GATE FIXED SHIELDING<br>(CS)                                             | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 16170          | 1051            | 17221            |
| 230720.1147AAM                          | HD-2<br>VIBRATING DEVICE                                                         | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 5390           | 350             | 5740             |
| 230720.1147ABB                          | HD-7<br>YOKE, FLOOR GATE & FLOOR<br>PLUG CASK                                    | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 1940400        | 126126          | 2066526          |
| 230720.1448AAD                          | CN-4<br>MCO HANDLING W/C<br>25 TON HOIST, 135' SPAN<br>(CS)                      | -----        |          |          |       |                |          |                  |                |                 |                  |
| SUBTOTAL 230720 COLD HANDLING EQUIPMENT |                                                                                  |              |          | 0        | 0     | 0              | 0        | 0                | 2,302,608      | 149,669         | 2,452,277        |
| -----                                   |                                                                                  |              |          |          |       |                |          |                  |                |                 |                  |
| SUBTOTAL 230 VAULTS 1, 2 & 3            |                                                                                  |              |          | 0        | 0     | 0              | 0        | 0                | 2,302,608      | 149,669         | 2,452,277        |

FLUOR DANIEL INC.  
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| WBS            | DESCRIPTION                                                                          | ESTIMATE<br>SUBTOTAL | ONSITE<br>INDIRECTS | SUB<br>TOTAL | ESCALATION<br>% | SUB<br>TOTAL | CONTINGENCY<br>% | CONTINGENCY<br>TOTAL | TOTAL<br>DOLLARS |
|----------------|--------------------------------------------------------------------------------------|----------------------|---------------------|--------------|-----------------|--------------|------------------|----------------------|------------------|
| 240050         | HVAC                                                                                 |                      |                     |              |                 |              |                  |                      |                  |
| 240050.1543AAD | EF-4<br>EXHAUST FAN<br>2000 CFM<br>1 HP                                              | 700                  | 1 EA                | 0            | 0               | 0            | 431              | 28                   | 459              |
| 240050.1544AAC | ACC-3<br>AIR COOLED CONDENSING UNIT<br>7 KW                                          | 700                  | 1 EA                | 0            | 0               | 0            | 3773             | 246                  | 4019             |
| 240050.1547AAD | AHU-5<br>AIR HANDLING UNIT<br>2000 CFM<br>3 HP                                       | 700                  | 1 EA                | 0            | 0               | 0            | 862              | 56                   | 918              |
| -----          |                                                                                      |                      |                     |              |                 |              |                  |                      |                  |
|                | SUBTOTAL 240050 HVAC                                                                 |                      | 0                   | 0            | 0               | 0            | 5,066            | 330                  | 5,396            |
| 240320         | ELECTRICAL DISTRIBUTION                                                              |                      |                     |              |                 |              |                  |                      |                  |
| 240320.1661AAA | XFMR #1<br>750KVA, 13.8-.48KV, 3 PHASE<br>4W, PAD MOUNTED, OIL FILLED<br>TRANSFORMER | 600                  | 1 EA                | 0            | 0               | 0            | 26950            | 1752                 | 28702            |
| 240320.1661AAB | SVGR #1<br>480V, 3 PHASE, 60 HZ, 1600 A<br>SWITCHGEAR                                | 600                  | 1 EA                | 0            | 0               | 0            | 64680            | 4204                 | 68884            |
| 240320.1661AAC | MCC #1 & #2<br>480V, 3 PHASE, 60 HZ, 300 A<br>MCC, TRIN A & B                        | 600                  | 2 EA                | 0            | 0               | 0            | 9486             | 617                  | 10103            |
| 240320.1661AAD | MCC #3 & #4<br>480V, 3 PHASE, 60 HZ, 800 A<br>MCC, TRIN A & B                        | 600                  | 2 EA                | 0            | 0               | 0            | 40748            | 2649                 | 43397            |
| 240320.1661AAE | UPS #1 & #2<br>3 KVA, 120V, 1 PHASE, 3W, W/<br>BATTERIES 15 MIN UPS                  | 600                  | 2 EA                | 0            | 0               | 0            | 10780            | 701                  | 11481            |
| 240320.1661AAF | UPS #3<br>10 KVA, 208/120V, 3 PHASE, 4W,<br>W/BATTERIES 15 MIN UPS                   | 600                  | 1 EA                | 0            | 0               | 0            | 16170            | 1051                 | 17221            |
| 240320.1661AAG | PNL PRD #1 THRU #4<br>15 KVA, 12 CKT, 480-208/120V,                                  | 600                  | 4 EA                | 0            | 0               | 0            | 17248            | 1121                 | 18369            |

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| ACCOUNT<br>NUMBER | DESCRIPTION                                                                                                                | COST<br>CODE | QUANTITY | MANHOURS | LABOR | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OH&P<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|----------------------------------------------------------------------------------------------------------------------------|--------------|----------|----------|-------|----------------|----------|------------------|----------------|-----------------|------------------|
| 240320.1661AAH    | 3 PHASE, 4W, PANEL BOARD,<br>FULLY EQUIPPED<br>ATS #1 & #2<br>300A, 480/277V,<br>3 PHASE, 4W, AUTOMATIC<br>TRANSFER SWITCH | 600          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 16170          | 1051            | 17221            |
| SUBTOTAL 240320   | ELECTRICAL DISTRIBUTION                                                                                                    |              |          | 0        | 0     | 0              | 0        | 0                | 202,232        | 13,146          | 215,378          |
| 240410            | INSTRUMENT AIR                                                                                                             |              |          |          |       |                |          |                  |                |                 |                  |
| 240410.1143AAA    | C-1A/B<br>AIR COMPRESSORS<br>BHP 25<br>(CS)                                                                                | 700          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 22638          | 1471            | 24109            |
| 240410.1143AAB    | DY-1<br>INSTRUMENT AIR DRYER<br>100 SCFM<br>(CS)                                                                           | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 31262          | 2032            | 33294            |
| 240410.1143AAC    | V-1<br>INSTRUMENT AIR RECEIVER<br>8'DIA X 8'T/T<br>(CS)                                                                    | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 21560          | 1401            | 22961            |
| SUBTOTAL 240410   | INSTRUMENT AIR                                                                                                             |              |          | 0        | 0     | 0              | 0        | 0                | 75,460         | 4,904           | 80,364           |
| 240480            | PROCESS WATER SYSTEM                                                                                                       |              |          |          |       |                |          |                  |                |                 |                  |
| 240480.1142AAG    | V-8<br>PROCESS WATER STORAGE TANK<br>7.5'DIA X 16'T/T<br>(304LSS)                                                          | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 12936          | 841             | 13777            |
| 240480.1146AAF    | P-7A/B<br>PROCESS WATER PUMPS<br>5 HP<br>(304LSS)                                                                          | 700          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 431            | 28              | 459              |
| SUBTOTAL 240480   | PROCESS WATER SYSTEM                                                                                                       |              |          | 0        | 0     | 0              | 0        | 0                | 13,367         | 869             | 14,236           |
| 240530            | LIQUID WASTE COLLECTION SYSTEM                                                                                             |              |          |          |       |                |          |                  |                |                 |                  |
| 240530.1142AAE    | V-6<br>WASTE WASHWATER HOLD TANK                                                                                           | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 7546           | 490             | 8036             |

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| ACCOUNT<br>NUMBER                           | DESCRIPTION                                                                                    | COST<br>CODE | QUANTITY | MANHOURS | LABOR | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OH&P<br>/ B & I | TOTAL<br>DOLLARS |
|---------------------------------------------|------------------------------------------------------------------------------------------------|--------------|----------|----------|-------|----------------|----------|------------------|----------------|-----------------|------------------|
| 240530.1146AAD                              | 6'DIA X 10' T/T<br>(CS W/EPOXY LINING)<br>P-4<br>WASTE WASHWATER SUMP PUMP<br>5 HP<br>(304LSS) | 700          | 1 EA     | 0        | 0     | 0              | 0        | 0                | 431            | 28              | 459              |
| SUBTOTAL 240530 LIQUID WASTE COLLECTION SYS |                                                                                                |              |          |          |       |                |          |                  |                |                 |                  |
| 240610                                      | DCS                                                                                            |              |          |          |       |                |          |                  | 7,977          | 518             | 8,495            |
| 240610.1771AAA                              | DCS                                                                                            | 700          | 1 LOT    | 0        | 0     | 0              | 0        | 0                | 134750         | 8759            | 143509           |
| SUBTOTAL 240610 DCS                         |                                                                                                |              |          |          |       |                |          |                  |                |                 |                  |
| 240620                                      | HEALTH PHYSICS SYSTEM                                                                          |              |          |          |       |                |          |                  |                |                 |                  |
| 240620.1143AAD                              | MS-1A/B<br>VACUUM SYSTEM BLOWERS<br>(CS)                                                       | 700          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 125264         | 8142            | 133406           |
| 240620.1147AAS                              | F-3A/B<br>VACUUM SYSTEM HEPA FILTERS<br>100 ACFM<br>(304LSS)                                   | 700          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 10133          | 659             | 10792            |
| 240620.1771AAB                              | HPS, HARDWARE                                                                                  | 700          | 1 LOT    | 0        | 0     | 0              | 0        | 0                | 1563100        | 101602          | 1664702          |
| 240620.1771AAC                              | HPS, SOFTWARE/CONFIGURATION                                                                    | 700          | 1 LOT    | 0        | 0     | 0              | 0        | 0                | 2285360        | 148548          | 2433908          |
| 240620.1771AAD                              | HPS, VENDOR SUPPORT                                                                            | 700          | 1 LOT    | 0        | 0     | 0              | 0        | 0                | 194040         | 12613           | 206653           |
| SUBTOTAL 240620 HEALTH PHYSICS SYSTEM       |                                                                                                |              |          |          |       |                |          |                  |                |                 |                  |
| 240720                                      | COLD HANDLING EQUIPMENT                                                                        |              |          |          |       |                |          |                  | 4,177,897      | 271,564         | 4,449,461        |
| 240720.1147ABC                              | SH-1<br>SHOP EQUIPMENT                                                                         | 755          | 1 LOT    | 0        | 0     | 0              | 0        | 0                | 53900          | 3504            | 57404            |
| 240720.1335AA1                              | SD-5A/B<br>SHIELD DOOR, PERSONNEL(DBL)<br>(5'X6'X7')                                           | 700          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 38808          | 2523            | 41331            |
| SUBTOTAL 240720 COLD HANDLING EQUIPMENT     |                                                                                                |              |          |          |       |                |          |                  |                |                 |                  |
| SUBTOTAL 240 PERSONNEL/UTILITY/SUPPORT A    |                                                                                                |              |          |          |       |                |          |                  |                |                 |                  |
|                                             |                                                                                                |              |          |          |       |                |          |                  | 92,708         | 6,027           | 98,735           |
| SUBTOTAL 240 PERSONNEL/UTILITY/SUPPORT A    |                                                                                                |              |          |          |       |                |          |                  |                |                 |                  |
|                                             |                                                                                                |              |          |          |       |                |          |                  | 4,709,457      | 306,117         | 5,015,574        |

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| WBS            | DESCRIPTION                 | ESTIMATE<br>SUBTOTAL | ONSITE<br>INDIRECTS | SUB<br>TOTAL | ESCALATION<br>% | SUB<br>TOTAL | CONTINGENCY<br>% | TOTAL<br>DOLLARS |
|----------------|-----------------------------|----------------------|---------------------|--------------|-----------------|--------------|------------------|------------------|
| 260050         | HVAC                        | 700                  | 2 EA                | 0            | 0               | 0            | 194040           | 12613            |
| 260050.1540AAA | PF-1A/B                     |                      |                     |              |                 |              |                  | 206653           |
|                | HEPA FILTER PLENUMS         |                      |                     |              |                 |              |                  |                  |
|                | 6000 CFM                    |                      |                     |              |                 |              |                  |                  |
| 260050.1540AAB | PF-2A/B                     | 700                  | 2 EA                | 0            | 0               | 0            | 301840           | 19620            |
|                | HEPA FILTER PLENUMS         |                      |                     |              |                 |              |                  |                  |
|                | 12000 CFM                   |                      |                     |              |                 |              |                  |                  |
| 260050.1540AAC | PF-3A/B                     | 700                  | 2 EA                | 0            | 0               | 0            | 129360           | 8408             |
|                | HEPA FILTER PLENUMS         |                      |                     |              |                 |              |                  |                  |
|                | 4000 CFM                    |                      |                     |              |                 |              |                  |                  |
| 260050.1543AAA | EF-1A/B                     | 700                  | 2 EA                | 0            | 0               | 0            | 15092            | 981              |
|                | EMERGENCY EXHAUST FANS      |                      |                     |              |                 |              |                  |                  |
|                | 6000 CFM                    |                      |                     |              |                 |              |                  |                  |
|                | 15 HP                       |                      |                     |              |                 |              |                  |                  |
| 260050.1543AAB | EF-2A/B                     | 700                  | 2 EA                | 0            | 0               | 0            | 12936            | 841              |
|                | RECIRC/EXHAUST FANS         |                      |                     |              |                 |              |                  |                  |
|                | 12000 CFM                   |                      |                     |              |                 |              |                  |                  |
|                | 25 HP                       |                      |                     |              |                 |              |                  |                  |
| 260050.1543AAC | EF-3A/B                     | 700                  | 2 EA                | 0            | 0               | 0            | 12936            | 841              |
|                | EXHAUST FANS                |                      |                     |              |                 |              |                  |                  |
|                | 4000 CFM                    |                      |                     |              |                 |              |                  |                  |
|                | 10 HP                       |                      |                     |              |                 |              |                  |                  |
| 260050.1543AAE | SF-1A/B                     | 700                  | 2 EA                | 0            | 0               | 0            | 32340            | 2102             |
|                | SUPPLY FANS                 |                      |                     |              |                 |              |                  |                  |
|                | 20000 CFM                   |                      |                     |              |                 |              |                  |                  |
|                | 10 HP                       |                      |                     |              |                 |              |                  |                  |
| 260050.1544AAA | ACC-1/2                     | 700                  | 2 EA                | 0            | 0               | 0            | 53900            | 3504             |
|                | AIR COOLED CONDENSING UNITS |                      |                     |              |                 |              |                  |                  |
|                | 50 KW                       |                      |                     |              |                 |              |                  |                  |
| 260050.1544AAD | EH-5 THRU 8                 | 700                  | 4 EA                | 0            | 0               | 0            | 3234             | 210              |
|                | ELECTRIC UNIT HEATERS       |                      |                     |              |                 |              |                  |                  |
|                | 10 KW                       |                      |                     |              |                 |              |                  |                  |
| 260050.1547AAA | AHU-1/2                     | 700                  | 2 EA                | 0            | 0               | 0            | 36652            | 2382             |
|                | AIR WASHERS                 |                      |                     |              |                 |              |                  |                  |
|                | 20000 CFM                   |                      |                     |              |                 |              |                  |                  |
|                | 30 HP                       |                      |                     |              |                 |              |                  |                  |
| 260050.1547AAB | AHU-3                       | 700                  | 1 EA                | 0            | 0               | 0            | 107800           | 7007             |
|                | KF OSA PURGE                |                      |                     |              |                 |              |                  |                  |
|                |                             |                      |                     |              |                 |              |                  | 114807           |



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| ACCOUNT<br>NUMBER | DESCRIPTION                                                                   | COST<br>CODE | QUANTITY | MANHOURS | LABOR | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>FMT | OH&P<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|-------------------------------------------------------------------------------|--------------|----------|----------|-------|----------------|----------|------------------|---------------|-----------------|------------------|
| 260050.1547AAC    | 9000 CFM<br>7.5 HP<br>AIR HANDLING UNITS<br>11000 CFM<br>15 HP                | 700          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 25872         | 1682            | 27554            |
| SUBTOTAL 260050   | HVAC EQUIPMENT AREA                                                           |              |          |          |       |                |          |                  | 926,002       | 60,191          | 986,193          |
| SUBTOTAL 260      |                                                                               |              |          |          |       |                |          |                  | 926,002       | 60,191          | 986,193          |
| 270520            | DRAIN LINES                                                                   |              |          |          |       |                |          |                  |               |                 |                  |
| 270520.1146AAG    | P-8A/B<br>DRAIN LINE PUMPS<br>5 HP<br>(CS)                                    | 700          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 10564         | 687             | 11251            |
| SUBTOTAL 270520   | DRAIN LINES                                                                   |              |          |          |       |                |          |                  | 10,564        | 687             | 11,251           |
| SUBTOTAL 270      | INFRASTRUCTURE                                                                |              |          |          |       |                |          |                  | 10,564        | 687             | 11,251           |
| 280320            | ELECTRICAL DISTRIBUTION                                                       |              |          |          |       |                |          |                  |               |                 |                  |
| 280320.1661AAI    | EG-1/2<br>EMERGENCY GENERATORS(80KV)<br>INCLUDING ALL ASSOCIATED<br>EQUIPMENT | 600          | 2 EA     | 0        | 0     | 0              | 0        | 0                | 114268        | 7427            | 121695           |
| SUBTOTAL 280320   | ELECTRICAL DISTRIBUTION                                                       |              |          |          |       |                |          |                  | 114,268       | 7,427           | 121,695          |
| SUBTOTAL 280      | POWER GENERATION                                                              |              |          |          |       |                |          |                  | 114,268       | 7,427           | 121,695          |
| SUBTOTAL 2        | PROCUREMENT                                                                   |              |          |          |       |                |          |                  | 11,015,001    | 715,978         | 11,730,979       |

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| ACCOUNT<br>NUMBER | DESCRIPTION                                                    | COST<br>CODE | QUANTITY | MANHOURS  | LABOR   | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | ONHP<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|----------------------------------------------------------------|--------------|----------|-----------|---------|----------------|----------|------------------|----------------|-----------------|------------------|
| 320010            | STRUCTURE                                                      |              |          |           |         |                |          |                  |                |                 |                  |
| 320010.0202001    | MACHINE EXCAVATION                                             | 501          | 9375 CY  | 656       | 18729   | 28931          | 0        | 0                | 0              | 9897            | 57557            |
| 320010.0202101    | HAND EXCAVATION                                                | 501          | 95 CY    | 95        | 2516    | 0              | 0        | 0                | 0              | 1077            | 3593             |
| 320010.0205002    | SINGLE TRACK RAILROAD<br>SPUR, INCL STEEL TIES<br>AND CONCRETE | 501          | 235 LF   | 540       | 16324   | 1211           | 21371    | 0                | 0              | 8455            | 47361            |
| 320010.0205003    | RAILROAD CAR BUMPER                                            | 501          | 2 EA     | 48        | 1451    | 107            | 4635     | 0                | 0              | 929             | 7122             |
| 320010.0313A10    | SLAB ON GRADE, > 36"                                           | 501          | 2260 CY  | 13557     | 400880  | 37961          | 292354   | 0                | 0              | 193047          | 924242           |
| 320010.0315A05    | WALLS, 12"-36"                                                 | 501          | 1910 CY  | 32483     | 960522  | 90952          | 354145   | 0                | 0              | 440035          | 1845654          |
| 320010.0315A30    | INTERIOR WALLS, 36"-60"                                        | 501          | 465 CY   | 6513      | 192589  | 18235          | 83211    | 0                | 0              | 89022           | 383057           |
| 320010.0315B10    | EXTERIOR WALLS, > 36"                                          | 501          | 300 CY   | 5396      | 159560  | 15108          | 64809    | 0                | 0              | 73487           | 312964           |
| 320010.0316B05    | ELEVATED SLABS, 12"-36"                                        | 501          | 545 CY   | 7633      | 225708  | 21373          | 80489    | 0                | 0              | 103224          | 430794           |
| 320010.0319201    | CONCRETE STAIRS                                                | 501          | 485 CY   | 6793      | 200869  | 19020          | 77379    | 0                | 0              | 92238           | 389506           |
| 320010.0319901    | WASTE AND SPILLAGE                                             | 501          | 120 CY   | 180       | 5323    | 504            | 7115     | 0                | 0              | 2773            | 15715            |
| 320010.0523002    | STAIRS                                                         | 501          | 57 RSR   | 132       | 4155    | 363            | 11724    | 0                | 0              | 2564            | 18806            |
| 320010.0525AAB    | STRUCTURAL STEEL, LT.                                          | 501          | 9 TON    | 207       | 6516    | 1999           | 22121    | 0                | 0              | 4357            | 34993            |
| 320010.0525AAD    | STRUCTURAL STEEL, HWY                                          | 501          | 63 TON   | 1008      | 31732   | 9737           | 85572    | 0                | 0              | 19776           | 146817           |
| 320010.0525AAK    | STRUCTURAL STEEL, METAL<br>DECK                                | 501          | 5800 SF  | 145       | 4565    | 1404           | 8066     | 0                | 0              | 2569            | 16604            |
| 320010.0529012    | RECTANGULAR EMBEDS                                             | 501          | 5 EA     | 100       | 3500    | 528            | 12052    | 0                | 0              | 2316            | 18396            |
| 320010.0529013    | CIRCULAR EMBEDS                                                | 501          | 28 EA    | 420       | 14700   | 2218           | 24962    | 0                | 0              | 8058            | 49938            |
| 320010.0529014    | CIRCULAR EMBEDS                                                | 501          | 3 EA     | 45        | 1575    | 238            | 4275     | 0                | 0              | 967             | 7055             |
| 320010.0529015    | RECTANGLE PLUGS                                                | 501          | 5 EA     | 75        | 2625    | 396            | 15690    | 0                | 0              | 2169            | 20880            |
| 320010.0529016    | CIRCULAR PLUGS                                                 | 501          | 28 EA    | 336       | 11760   | 1774           | 28735    | 0                | 0              | 7016            | 49285            |
| 320010.0529017    | CIRCULAR PLUGS                                                 | 501          | 3 EA     | 36        | 1260    | 190            | 5246     | 0                | 0              | 893             | 7589             |
| 320010.0832001    | 3 X 7 M M DOOR                                                 | 501          | 11 EA    | 88        | 2685    | 191            | 6403     | 0                | 0              | 1578            | 10857            |
| 320010.0832008    | 5 X 10 M M DOOR                                                | 501          | 5 PR     | 70        | 2136    | 152            | 12128    | 0                | 0              | 1712            | 16128            |
| 320010.0932015    | SANITARY COVE                                                  | 501          | 945 LF   | 189       | 5538    | 147            | 4024     | 0                | 0              | 2641            | 12350            |
| 320010.0932016    | 6" HIGH<br>FILLER                                              | 501          | 28 CF    | 126       | 3692    | 161            | 1109     | 0                | 0              | 1663            | 6625             |
| 320010.0981023    | PAINTING                                                       | 501          | 22084 SF | 1325      | 34848   | 1700           | 13093    | 0                | 0              | 15877           | 65518            |
| 320010.0981024    | SEALER/HARDNER                                                 | 501          | 62810 SF | 879       | 23118   | 628            | 20313    | 0                | 0              | 11256           | 55315            |
| 320010.0981025    | COAT FLOOR                                                     | 501          | 13765 SF | 1776      | 46709   | 1514           | 81019    | 0                | 0              | 25356           | 154598           |
| 320010.0981026    | COAT CEILING/WALLS                                             | 501          | 46190 SF | 4989      | 131211  | 6467           | 75685    | 0                | 0              | 61498           | 274861           |
| 320010.0984006    | SANDBLAST                                                      | 501          | 59995 SF | 3840      | 110630  | 5400           | 25870    | 0                | 0              | 49383           | 191283           |
| 320010.1662H52    | GROUNDING                                                      | 501          | 1 LOT    | 147       | 5145    | 331            | 2336     | 0                | 0              | 2375            | 10187            |
| 320010.1662H53    | LIGHTNING PROTECTION                                           | 501          | 1 LOT    | 290       | 10150   | 653            | 2870     | 0                | 0              | 4573            | 18246            |
| SUBTOTAL 320010   | STRUCTURE                                                      |              | 90,117   | 2,642,721 | 269,593 | 1,448,801      | 0        | 0                | 1,242,781      | 5,603,896       |                  |

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|-----------------------------------------|-----------------------------------------------------------|--------------|----------|----------|-------|----------------|----------|------------------|----------------|-----------------|------------------|
| 320040                                  | FIRE PROTECTION                                           |              |          |          |       |                |          |                  |                |                 |                  |
| 320040.1559001                          | SPRINKLER SYSTEM<br>(SF ALLOWANCE)                        | 501          | 13765 SF | 826      | 26151 | 2230           | 17065    | 0                | 0              | 12447           | 57893            |
| SUBTOTAL 320040 FIRE PROTECTION         |                                                           |              |          |          |       |                |          |                  |                |                 |                  |
| 320050                                  | HVAC                                                      |              |          |          |       |                |          |                  |                |                 |                  |
| 320050.1528AA1                          | GALV DUCTING FOR CASK<br>RECEIVING AREA                   | 700          | 1 LOT    | 960      | 30758 | 1574           | 16170    | 0                | 0              | 14318           | 62820            |
| 320050.1528AA5                          | SS DUCTING FOR CASK<br>RECEIVING AREA                     | 700          | 1 LOT    | 2100     | 67284 | 3444           | 35574    | 0                | 0              | 31333           | 137635           |
| 320050.1544AA2                          | EH-1 THRU 4<br>ELECTRIC UNIT HEATERS<br>10 KW             | 700          | 4 EA     | 40       | 1427  | 386            | 0        | 0                | 0              | 636             | 2449             |
| 320050.1549AA1                          | RV-1 THRU 4<br>POWER ROOF VENTILATORS<br>4000 CFM<br>2 HP | 501          | 4 EA     | 80       | 2854  | 773            | 0        | 0                | 0              | 1272            | 4899             |
| 320050.1662N60                          | HVAC ELECTRICAL                                           | 700          | 1 LOT    | 1364     | 43703 | 3071           | 42073    | 0                | 0              | 21639           | 110486           |
| SUBTOTAL 320050 HVAC                    |                                                           |              |          |          |       |                |          |                  |                |                 |                  |
| 320210                                  | MCO SERVICE STATIONS                                      |              |          |          |       |                |          |                  |                |                 |                  |
| 320210.1147AA1                          | SR-1<br>W2 CYLINDER RACK<br>(CS)                          | 700          | 1 EA     | 100      | 3186  | 319            | 0        | 0                | 0              | 1384            | 4889             |
| SUBTOTAL 320210 MCO SERVICE STATIONS    |                                                           |              |          |          |       |                |          |                  |                |                 |                  |
| 320320                                  | ELECTRICAL DISTRIBUTION                                   |              |          |          |       |                |          |                  |                |                 |                  |
| 320320.1662H50                          | AREA LIGHTING                                             | 501          | 13765 SF | 1184     | 41440 | 2202           | 42439    | 0                | 0              | 20638           | 106719           |
| 320320.1662N61                          | NORMAL ELECTRICAL DIST                                    | 501          | 1 LOT    | 613      | 19641 | 1379           | 17003    | 0                | 0              | 9601            | 47624            |
| 320320.1664604                          | ELECTRICAL EMBEDS IN TUNNEL<br>304LSS, 2" DIA, 10' LONG   | 700          | 20 EA    | 800      | 27960 | 2320           | 10780    | 0                | 0              | 12819           | 53879            |
| SUBTOTAL 320320 ELECTRICAL DISTRIBUTION |                                                           |              |          |          |       |                |          |                  |                |                 |                  |
| 320650                                  | COMMUNICATIONS                                            |              |          |          |       |                |          |                  |                |                 |                  |
| 320650.1662H51                          | COMMUNICATION                                             | 501          | 13765 SF | 564      | 19740 | 413            | 4600     | 0                | 0              | 8775            | 33528            |

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FLUOR DANIEL INC.  
WESTINGHOUSE HANFORD COMPANY  
JOB NO. 04436307

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SNF CANISTER STORAGE BUILDING  
CONCEPTUAL DESIGN ESTIMATE, JULY 21, 1995  
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| ACCOUNT<br>NUMBER | DESCRIPTION                                     | COST<br>CODE | QUANTITY | MANHOURS | LABOR  | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | ONR<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|-------------------------------------------------|--------------|----------|----------|--------|----------------|----------|------------------|----------------|----------------|------------------|
|                   |                                                 |              |          | 564      | 19,740 | 413            | 4,600    | 0                | 0              | 8,775          | 33,528           |
| SUBTOTAL          | 320650 COMMUNICATIONS                           |              |          |          |        |                |          |                  |                |                |                  |
| 320720            | COLD HANDLING EQUIPMENT                         |              |          |          |        |                |          |                  |                |                |                  |
| 320720.1147A17    | SS-1                                            | 700          | 1 EA     | 200      | 6560   | 1932           | 0        | 0                | 0              | 2933           | 11425            |
| 320720.1147A18    | MCO SERVICE STATION<br>TV-1A/B/C<br>CCTV        | 700          | 3 EA     | 240      | 7872   | 2318           | 0        | 0                | 0              | 3520           | 13710            |
| 320720.1147A20    | HA-4<br>HATCH CASK ENTRANCE<br>60" DIA<br>(CS)  | 700          | 1 EA     | 80       | 2624   | 773            | 0        | 0                | 0              | 1173           | 4570             |
| 320720.1147A21    | SA-1<br>CASK, INTERNAL SAMLING EQUIP            | 700          | 1 EA     | 200      | 6560   | 1932           | 0        | 0                | 0              | 2933           | 11425            |
| 320720.1147A22    | HD-1<br>LANCES                                  | 700          | 1 LOT    | 100      | 3280   | 966            | 0        | 0                | 0              | 1467           | 5713             |
| 320720.1147A24    | HD-3<br>GRAPPLE                                 | 700          | 1 EA     | 40       | 1312   | 386            | 0        | 0                | 0              | 587            | 2285             |
| 320720.1147A25    | WR-1<br>WASH RACK                               | 700          | 1 EA     | 80       | 2624   | 773            | 0        | 0                | 0              | 1173           | 4570             |
| 320720.1147A26    | HD-4<br>YOKE TRANSPORT CASK                     | 700          | 1 EA     | 40       | 1312   | 386            | 0        | 0                | 0              | 587            | 2285             |
| 320720.1147A27    | HD-6<br>MCO HANDLING DEVICE(EMPTY)              | 700          | 1 EA     | 40       | 1312   | 386            | 0        | 0                | 0              | 587            | 2285             |
| 320720.1147A30    | HD-8<br>RAILCAR MOVING DEVICE                   | 700          | 1 EA     | 80       | 2624   | 773            | 0        | 0                | 0              | 1173           | 4570             |
| 320720.1147AA2    | SR-2<br>STORAGE RACK<br>28/1/2<br>(304LSS)      | 700          | 1 EA     | 100      | 3186   | 319            | 0        | 0                | 0              | 1384           | 4889             |
| 320720.1335A10    | SD-6A/B<br>SHIELD DOOR, PERSONNEL<br>(4"X3'X7') | 700          | 2 EA     | 200      | 6234   | 1022           | 0        | 0                | 0              | 2735           | 9991             |
| 320720.1335A11    | SD-6C<br>SHIELD DOOR, PERSONNEL<br>(4"X3'X7')   | 700          | 1 EA     | 100      | 3117   | 511            | 0        | 0                | 0              | 1367           | 4995             |
| 320720.1335A12    | SD-7<br>SHIELD DOOR, PERSONNEL<br>(4"X3'X7')    | 700          | 1 EA     | 100      | 3117   | 511            | 0        | 0                | 0              | 1367           | 4995             |
| 320720.1335A13    | SD-9<br>SHIELD DOOR, TUNNEL                     | 700          | 1 EA     | 100      | 3117   | 511            | 0        | 0                | 0              | 1367           | 4995             |

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WESTINGHOUSE HANFORD COMPANY  
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| ACCOUNT<br>NUMBER | DESCRIPTION                                                                       | COST<br>CODE | QUANTITY | HANHOURS | LABOR | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OH&P<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|-----------------------------------------------------------------------------------|--------------|----------|----------|-------|----------------|----------|------------------|----------------|-----------------|------------------|
| 320720.1335AA1    | (8"X3'X7')<br>SD-1A/B<br>SHIELD DOOR<br>5"X12'X20'<br>(CS)                        | 700          | 2 EA     | 200      | 6234  | 1022           | 0        | 0                | 0              | 2735            | 9991             |
| 320720.1335AA2    | SZ-1C THRU G<br>SHIELD WINDOWS W/WALL LINER<br>& FRAME                            | 700          | 5 EA     | 800      | 23960 | 2532           | 0        | 0                | 0              | 10419           | 36911            |
| 320720.1335AA3    | SD-2A/B<br>SHIELD DOOR<br>4"X12'X20'<br>(CS)                                      | 700          | 2 EA     | 200      | 6234  | 1022           | 0        | 0                | 0              | 2735            | 9991             |
| 320720.1335AA4    | SD-3<br>SHIELD DOOR<br>4"X6'X20'<br>(CS)                                          | 700          | 1 EA     | 100      | 3117  | 511            | 0        | 0                | 0              | 1367            | 4995             |
| 320720.1335AA5    | SZ-1A/B<br>SHIELD WINDOWS W/WALL LINER<br>& FRAME                                 | 700          | 2 EA     | 320      | 9584  | 1013           | 0        | 0                | 0              | 4168            | 14765            |
| 320720.1335AA6    | SD-8<br>SHIELD DOOR, TUNNEL<br>(4"X3'X7')                                         | 700          | 1 EA     | 100      | 3117  | 511            | 0        | 0                | 0              | 1367            | 4995             |
| 320720.1335AA7    | SD-4A<br>SHIELD DOOR, PERSONNEL<br>(5"X3'X7')                                     | 700          | 1 EA     | 100      | 3117  | 511            | 0        | 0                | 0              | 1367            | 4995             |
| 320720.1335AA8    | SD-4B<br>SHIELD DOOR, PERSONNEL<br>(5"X3'X7')                                     | 700          | 1 EA     | 100      | 3117  | 511            | 0        | 0                | 0              | 1367            | 4995             |
| 320720.1448AA1    | CN-1<br>BRIDGE CRANE, TRANSPORT CASK<br>40 TON MAIN W/10 TON AUX<br>40' SPAN (CS) | 700          | 1 EA     | 800      | 25248 | 7431           | 0        | 0                | 0              | 11289           | 43968            |
| 320720.1448AA3    | CN-3<br>JIB CRANE, CASK LOADING PIT<br>10 TON W/6' BOOM<br>(CS)                   | 700          | 1 EA     | 40       | 1262  | 386            | 0        | 0                | 0              | 565             | 2213             |
| 320720.1448AA5    | CN-5A/B<br>CART TRANSFER CASK<br>30 TON<br>(SS & CS)                              | 700          | 1 EA     | 160      | 5050  | 1533           | 0        | 0                | 0              | 2261            | 8844             |
| 320720.1448AA6    | CN-6<br>CRANE UNDER HUNG                                                          | 700          | 1 EA     | 80       | 2525  | 773            | 0        | 0                | 0              | 1131            | 4429             |

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| ACCOUNT<br>NUMBER | DESCRIPTION                                                                                                       | COST<br>CODE | QUANTITY | HANHOURS  | LABOR     | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | ONHP<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|-------------------------------------------------------------------------------------------------------------------|--------------|----------|-----------|-----------|----------------|----------|------------------|----------------|-----------------|------------------|
|                   | 5 TON, 38' SPAN<br>(CS)                                                                                           |              |          | 4,700     | 147,416   | 31,255         | 0        | 0                | 0              | 65,124          | 243,795          |
| SUBTOTAL          | 320720 COLD HANDLING EQUIPMENT                                                                                    |              |          |           |           |                |          |                  |                |                 |                  |
|                   |                                                                                                                   |              |          | 103,448   | 318,959   | 0              | 0        | 0                | 0              | 1,442,767       | 6,470,512        |
| SUBTOTAL          | 320 CASK RECEIVING AREA                                                                                           |              |          | 3,074,281 | 1,634,505 |                |          |                  |                |                 |                  |
| 330010            | STRUCTURE                                                                                                         |              |          |           |           |                |          |                  |                |                 |                  |
| 330010.0201002    | MASS EXCAVATION VAULT &<br>PLENUM AREA(NO COST, EXCAV<br>WAS PERFORMED BY PKG 210-01<br>CONTRACTOR, HWP PROJ)     | 501          | 0        | 0         | 0         | 0              | 0        | 0                | 0              | 0               | 0                |
| 330010.0313001    | CONC MUD MAT(589 CY) FOR<br>VAULT/PLENUM AREA(NO COST,<br>WAS PERFORMED BY PKG 350-01<br>CONTRACTOR, HWP PROJ)    | 501          | 0        | 0         | 0         | 0              | 0        | 0                | 0              | 0               | 0                |
| 330010.0313010    | SLAB ON GRADE (6252 CY) FOR<br>VAULT/PLENUM AREA(NO COST,<br>WAS PERFORMED BY PKG 350-01<br>CONTRACTOR, HWP PROJ) | 501          | 0        | 0         | 0         | 0              | 0        | 0                | 0              | 0               | 0                |
| 330010.0313020    | CONCRETE WALL > 36" (330 CY)<br>(NO COST, WAS PERFORMED BY<br>PKG 350-01 CONTRACTOR, HWP<br>PROJECT)              | 501          | 0        | 0         | 0         | 0              | 0        | 0                | 0              | 0               | 0                |
| 330010.0313030    | CONCRETE COLUMN (110 CY)<br>(NO COST, WAS PERFORMED BY<br>PKG 350-01 CONTRACTOR, HWP<br>PROJECT)                  | 501          | 0        | 0         | 0         | 0              | 0        | 0                | 0              | 0               | 0                |
| 330010.0315025    | INTERIOR WALLS, 12"-36"                                                                                           | 501          | 1680 CY  | 30216     | 893487    | 84605          | 315121   | 0                | 0              | 408395          | 1701608          |
| 330010.0315030    | INTERIOR WALLS, 36"-60"                                                                                           | 501          | 2005 CY  | 28081     | 830355    | 78628          | 358791   | 0                | 0              | 383824          | 1651598          |
| 330010.0315A05    | WALLS, 12"-36"                                                                                                    | 501          | 510 CY   | 8673      | 256461    | 24286          | 94562    | 0                | 0              | 117491          | 492800           |
| 330010.0315B10    | EXTERIOR WALLS, > 36"                                                                                             | 501          | 4095 CY  | 73651     | 2177860   | 206224         | 884648   | 0                | 0              | 1003031         | 4271763          |
| 330010.0316005    | ELEVATED SLABS, 12"-36"                                                                                           | 501          | 300 CY   | 4202      | 124253    | 11765          | 44306    | 0                | 0              | 56825           | 237149           |
| 330010.0316010    | ELEVATED SLABS, > 36"                                                                                             | 501          | 5655 CY  | 113100    | 3344367   | 190082         | 816876   | 0                | 0              | 1496841         | 5848166          |
| 330010.0316100    | CONCRETE IN PLUGS                                                                                                 | 501          | 1060 CY  | 2120      | 62688     | 35630          | 62847    | 0                | 0              | 33232           | 194397           |
| 330010.0316X10    | EXTERIOR WALLS, > 36"<br>ADDITIONAL 2" CONC TO EXTEND<br>THE DESIGN LIFE OF SAFETY                                | 501          | 750 CY   | 13489     | 398870    | 37770          | 162023   | 0                | 0              | 183703          | 782366           |

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| ACCOUNT<br>NUMBER | DESCRIPTION                                                                 | COST<br>CODE | QUANTITY | HANMOURS | LABOR   | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | ONEP<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|-----------------------------------------------------------------------------|--------------|----------|----------|---------|----------------|----------|------------------|----------------|-----------------|------------------|
| 330010.0319001    | CLASS STRUCT TO 200 YRS                                                     | 501          |          |          |         |                |          |                  |                |                 |                  |
| 330010.0319901    | TUNNEL OVER 36"                                                             | 501          | 305 CY   | 3966     | 117275  | 11105          | 46359    | 0                | 0              | 53929           | 228668           |
| 330010.0333100    | WASTE AND SPILLAGE                                                          | 501          | 320 CY   | 480      | 14194   | 1344           | 18973    | 0                | 0              | 7395            | 41906            |
| 330010.0333100    | ALLOWANCE FOR CHEMICAL                                                      | 501          | 1 LOT    | 0        | 0       | 0              | 0        | 25000            | 0              | 2500            | 27500            |
| 330010.0333200    | TESTING OF SOILS AROUND CSB                                                 |              |          |          |         |                |          |                  |                |                 |                  |
| 330010.0333200    | ALLOWANCE FOR CONSULTANT                                                    | 501          | 1 LOT    | 0        | 0       | 0              | 0        | 30000            | 0              | 3000            | 33000            |
| 330010.0333200    | FOR CONCRETE MIX DESIGN AND AGING EFFECTS                                   |              |          |          |         |                |          |                  |                |                 |                  |
| 330010.0333300    | (200 YR LIFE EXTENSION ALLW)                                                | 501          | 1 LOT    | 0        | 0       | 0              | 0        | 50000            | 0              | 5000            | 55000            |
| 330010.0333300    | ALLOWANCE FOR ADDITIONAL PHYSICAL AND CHEMICAL TESTING OF CONC AGGREGATES   |              |          |          |         |                |          |                  |                |                 |                  |
| 330010.03333E1    | (200 YR LIFE EXTENSION ALLW)                                                | 501          | 100 CY   | 2717     | 80342   | 9700           | 7826     | 0                | 0              | 35526           | 133394           |
| 330010.03333E1    | ALLOWANCE: SHOTCRETE ADDITIONAL 2" CONC TO EXTEND THE DESIGN LIFE OF SAFETY |              |          |          |         |                |          |                  |                |                 |                  |
| 330010.0525AAB    | CLASS STRUCT TO 200 YRS                                                     | 501          |          |          |         |                |          |                  |                |                 |                  |
| 330010.0525AAB    | STRUCTURAL STEEL, LT.                                                       | 501          | 41 TON   | 943      | 29686   | 9105           | 100771   | 0                | 0              | 19848           | 159410           |
| 330010.0525AAC    | STRUCTURAL STEEL, MED.                                                      | 501          | 115 TON  | 2185     | 68784   | 21120          | 195873   | 0                | 0              | 43544           | 329321           |
| 330010.0525AAD    | STRUCTURAL STEEL, Hvy                                                       | 501          | 373 TON  | 5968     | 187873  | 57651          | 506638   | 0                | 0              | 117089          | 869251           |
| 330010.0525AAF    | STRUCTURAL STEEL, LADDERS W/CAGE                                            | 501          | 1 TON    | 60       | 1889    | 578            | 4635     | 0                | 0              | 1148            | 8250             |
| 330010.0525AAK    | STRUCTURAL STEEL, METAL DECK                                                | 501          | 27744 SF | 694      | 21847   | 6714           | 38582    | 0                | 0              | 12294           | 79437            |
| 330010.0525AAM    | STAINLESS STEEL CLOTH                                                       | 501          | 1100 SF  | 1100     | 34628   | 10626          | 23716    | 0                | 0              | 17053           | 86023            |
| 330010.0525AAN    | EXHAUST STACK(CORTEN)                                                       | 501          | 67 TON   | 1340     | 42183   | 25889          | 232568   | 0                | 0              | 34854           | 335494           |
| 330010.0525AAO    | INTAKE STRUCTURE(CORTEN)                                                    | 501          | 106 TON  | 4240     | 133475  | 40958          | 367943   | 0                | 0              | 83705           | 626081           |
| 330010.0529001    | EMBEDDED ANGLE                                                              | 501          | 660 EA   | 1353     | 46002   | 13068          | 28338    | 0                | 0              | 22380           | 109788           |
| 330010.0529002    | PLUG INSERT                                                                 | 501          | 660 EA   | 5280     | 179520  | 27878          | 0        | 0                | 0              | 78647           | 286045           |
| 330010.0529003    | CLOSE CONCRETE PORTS                                                        | 501          | 660 EA   | 660      | 22440   | 6376           | 0        | 0                | 0              | 10019           | 38835            |
| 330010.0529004    | EMBEDDED SLEEVE                                                             | 501          | 660 EA   | 3960     | 134640  | 41342          | 0        | 0                | 0              | 60313           | 236295           |
| 330010.0529006    | BOLTS, NUTS & ETC.                                                          | 501          | 1 LOT    | 0        | 0       | 0              | 26411    | 0                | 0              | 1717            | 28128            |
| 330010.0529007    | EMBEDDED ANGLE                                                              | 501          | 17 EA    | 39       | 1326    | 377            | 852      | 0                | 0              | 647             | 3202             |
| 330010.0529008    | PLUG INSERT                                                                 | 501          | 17 EA    | 136      | 4624    | 718            | 0        | 0                | 0              | 2026            | 7368             |
| 330010.0529009    | CLOSE CONCRETE PORTS                                                        | 501          | 17 EA    | 17       | 578     | 164            | 0        | 0                | 0              | 258             | 1000             |
| 330010.0529010    | TOP EMBEDDED SLEEVE                                                         | 501          | 17 EA    | 238      | 8092    | 1242           | 0        | 0                | 0              | 3544            | 12878            |
| 330010.0529011    | BOTTOM EMBEDDED SLEEVE                                                      | 501          | 17 EA    | 238      | 8092    | 1242           | 0        | 0                | 0              | 3544            | 12878            |
| 330010.0529012    | DAVITS ON STACK                                                             | 501          | 3 EA     | 45       | 1530    | 65             | 2749     | 0                | 0              | 838             | 5182             |
| 330010.0529AA1    | STANDARD CANISTER TUBE                                                      | 501          | 440 EA   | 35200    | 1108096 | 266464         | 6261024  | 0                | 0              | 898552          | 8534136          |
| 330010.0529AA3    | INCL TUBE BELLOW, PLUG INTERVALS & THERMOCOUPLES                            | 501          | 12 EA    | 960      | 30221   | 7267           | 178517   | 0                | 0              | 25011           | 241016           |
| 330010.0529AA3    | OVERPACK CANISTER TUBE INCL TUBE BELLOW, PLUG                               |              |          |          |         |                |          |                  |                |                 |                  |

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| ACCOUNT<br>NUMBER                       | DESCRIPTION                               | COST<br>CODE | QUANTITY  | MANHOURS   | LABOR      | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OH&P<br>/ B & I | TOTAL<br>DOLLARS |
|-----------------------------------------|-------------------------------------------|--------------|-----------|------------|------------|----------------|----------|------------------|----------------|-----------------|------------------|
| INTERNAL & THERMOCOUPLES                |                                           |              |           |            |            |                |          |                  |                |                 |                  |
| 330010.0731001                          | MEMBRANE ROOFING                          | 501          | 27745 SF  | 444        | 11233      | 416            | 40976    | 0                | 0              | 7498            | 60123            |
| 330010.0783101                          | ROOF INSULATION                           | 501          | 27745 SF  | 333        | 11165      | 250            | 32601    | 0                | 0              | 6914            | 50930            |
| 330010.0783102                          | INSULATED SIDING                          | 501          | 37740 SF  | 4151       | 126647     | 9020           | 209521   | 0                | 0              | 68410           | 413598           |
| 330010.0832001                          | 3 X 7 H M DOOR                            | 501          | 3 EA      | 24         | 732        | 52             | 1746     | 0                | 0              | 430             | 2960             |
| 330010.0834003                          | TELESCOPING DOOR                          | 501          | 1 EA      | 141        | 4395       | 720            | 22638    | 0                | 0              | 3399            | 31152            |
| 330010.0981023                          | PAINTING                                  | 501          | 187225 SF | 11234      | 295454     | 14416          | 111006   | 0                | 0              | 134607          | 555483           |
| 330010.0981024                          | SEALER/HARDNER                            | 501          | 133625 SF | 1871       | 49207      | 1336           | 43215    | 0                | 0              | 23956           | 117714           |
| 330010.1662H52                          | GROUNDING                                 | 501          | 1 LOT     | 300        | 10500      | 675            | 4709     | 0                | 0              | 4844            | 20728            |
| 330010.1662H53                          | LIGHTNING PROTECTION                      | 501          | 1 LOT     | 585        | 20475      | 1316           | 5785     | 0                | 0              | 9225            | 36801            |
| SUBTOTAL 330010 STRUCTURE               |                                           |              |           | 364,434    | 1,258,184  |                | 105,000  |                  | 5,487,006      |                 | 28,998,822       |
| 330040                                  | FIRE PROTECTION                           |              |           | 10,895,486 | 11,253,146 |                |          |                  |                |                 |                  |
| 330040.1559001                          | SPRINKLER SYSTEM<br>(SF ALLOWANCE)        | 501          | 27745 SF  | 1665       | 52714      | 4495           | 34396    | 0                | 0              | 25090           | 116695           |
| SUBTOTAL 330040 FIRE PROTECTION         |                                           |              |           | 1,665      | 52,714     | 4,495          | 34,396   | 0                | 0              | 25,090          | 116,695          |
| 330050                                  | HVAC                                      |              |           |            |            |                |          |                  |                |                 |                  |
| 330050.1528AA2                          | GALV DUCTING FOR VAULTS 1,2<br>AND 3 AREA | 700          | 1 LOT     | 3180       | 101887     | 5215           | 52822    | 0                | 0              | 47380           | 207304           |
| 330050.1662H60                          | HVAC ELECTRICAL                           | 700          | 1 LOT     | 3215       | 103009     | 7334           | 99149    | 0                | 0              | 51009           | 260501           |
| SUBTOTAL 330050 HVAC                    |                                           |              |           | 6,395      | 204,896    | 12,549         | 151,971  | 0                | 0              | 98,389          | 467,805          |
| 330320                                  | ELECTRICAL DISTRIBUTION                   |              |           |            |            |                |          |                  |                |                 |                  |
| 330320.1662H50                          | AREA LIGHTING                             | 501          | 27745 SF  | 2386       | 83510      | 4439           | 85540    | 0                | 0              | 41591           | 215080           |
| 330320.1662H61                          | NORMAL ELECTRICAL DIST                    | 501          | 1 LOT     | 1444       | 46266      | 3249           | 40070    | 0                | 0              | 22617           | 112202           |
| SUBTOTAL 330320 ELECTRICAL DISTRIBUTION |                                           |              |           | 3,830      | 129,776    | 7,688          | 125,610  | 0                | 0              | 64,208          | 327,282          |
| 330650                                  | COMMUNICATIONS                            |              |           |            |            |                |          |                  |                |                 |                  |
| 330650.1662H51                          | COMMUNICATION                             | 501          | 27745 SF  | 1138       | 39830      | 832            | 9272     | 0                | 0              | 17704           | 67638            |
| SUBTOTAL 330650 COMMUNICATIONS          |                                           |              |           | 1,138      | 39,830     | 832            | 9,272    | 0                | 0              | 17,704          | 67,638           |
| 330720                                  | COLD HANDLING EQUIPMENT                   |              |           |            |            |                |          |                  |                |                 |                  |
| 330720.1147A14                          | CK-2<br>FLASK, FLOOR PLUG                 | 700          | 1 EA      | 200        | 6560       | 1932           | 0        | 0                | 0              | 2933            | 11425            |

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FLUOR DANIEL INC.  
WESTINGHOUSE HANFORD COMPANY  
JOB NO. 04436307

\*\* TEST - INTERACTIVE ESTIMATING \*\*  
SNF CANISTER STORAGE BUILDING  
CONCEPTUAL DESIGN ESTIMATE, JULY 21, 1995  
D1 - ESTIMATE DETAIL BY MBS

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| ACCOUNT<br>NUMBER | DESCRIPTION                                                | COST<br>CODE | QUANTITY | MANHOURS | LABOR | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | ORHP<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|------------------------------------------------------------|--------------|----------|----------|-------|----------------|----------|------------------|----------------|-----------------|------------------|
| 330720.1147A15    | (CS)<br>GATE PORTABLE SHIELDING                            | 700          | 1 EA     | 100      | 3280  | 966            | 0        | 0                | 0              | 1467            | 5713             |
| 330720.1147A16    | (CS)<br>GATE FIXED SHIELDING                               | 700          | 1 EA     | 100      | 3280  | 966            | 0        | 0                | 0              | 1467            | 5713             |
| 330720.1147A23    | (CS)<br>VIBRATING DEVICE                                   | 700          | 1 EA     | 200      | 6560  | 1932           | 0        | 0                | 0              | 2933            | 11425            |
| 330720.1147A28    | ND-2<br>YOKE, FLOOR GATE & FLOOR<br>PLUG CASK              | 700          | 1 EA     | 40       | 1312  | 386            | 0        | 0                | 0              | 587             | 2285             |
| 330720.1448AA4    | CN-4<br>MCO HANDLING M/C<br>25 TON HOIST 135' SPAN<br>(CS) | 700          | 1 EA     | 800      | 25248 | 7431           | 0        | 0                | 0              | 11289           | 43968            |

SUBTOTAL 330720 COLD HANDLING EQUIPMENT

|            |            |         |           |   |            |        |
|------------|------------|---------|-----------|---|------------|--------|
| 1,440      | 46,240     | 13,613  | 0         | 0 | 20,676     | 80,529 |
| 378,902    | 1,297,361  | 105,000 | 5,713,073 | 0 | 30,058,771 |        |
| 11,368,942 | 11,574,395 |         |           |   |            |        |

SUBTOTAL 330 VAULTS 1, 2 & 3

340010 STRUCTURE

|                |                                 |     |         |      |       |      |       |   |   |       |        |
|----------------|---------------------------------|-----|---------|------|-------|------|-------|---|---|-------|--------|
| 340010.0202001 | MACHINE EXCAVATION              | 501 | 1060 CY | 74   | 2113  | 3271 | 0     | 0 | 0 | 1117  | 6501   |
| 340010.0202101 | HAND EXCAVATION                 | 501 | 10 CY   | 10   | 265   | 0    | 0     | 0 | 0 | 113   | 378    |
| 340010.0311001 | SPREAD FOOTINGS                 | 501 | 140 CY  | 1120 | 33118 | 3136 | 18714 | 0 | 0 | 15595 | 70563  |
| 340010.0312001 | FOUNDATION                      | 501 | 20 CY   | 180  | 5323  | 504  | 3363  | 0 | 0 | 2530  | 11720  |
| 340010.0313001 | SLAB ON GRADE, < 12"            | 501 | 130 CY  | 650  | 19221 | 1820 | 16677 | 0 | 0 | 9428  | 47146  |
| 340010.0313A05 | SHIELDING WALL                  | 501 | 130 CY  | 910  | 26909 | 2547 | 17658 | 0 | 0 | 12830 | 59944  |
| 340010.0319001 | WASTE AND SPILLAGE              | 501 | 8 CY    | 12   | 355   | 34   | 474   | 0 | 0 | 185   | 1048   |
| 340010.0523002 | STAIRS                          | 501 | 57 RSR  | 132  | 4155  | 363  | 11724 | 0 | 0 | 2564  | 18806  |
| 340010.0525AAB | STRUCTURAL STEEL, LT.           | 501 | 7 TON   | 161  | 5068  | 1554 | 17205 | 0 | 0 | 3389  | 27216  |
| 340010.0525AAC | STRUCTURAL STEEL, MED.          | 501 | 33 TON  | 627  | 19738 | 6060 | 56207 | 0 | 0 | 12495 | 94500  |
| 340010.0525AAD | STRUCTURAL STEEL, Hvy           | 501 | 55 TON  | 880  | 27702 | 8501 | 74705 | 0 | 0 | 17265 | 128173 |
| 340010.0525AAK | STRUCTURAL STEEL, METAL<br>DECK | 501 | 6983 SF | 175  | 5509  | 1690 | 9711  | 0 | 0 | 3099  | 20009  |
| 340010.0731001 | MEMBRANE ROOFING                | 501 | 6985 SF | 112  | 2834  | 105  | 10315 | 0 | 0 | 1891  | 15145  |
| 340010.0783101 | ROOF INSULATION                 | 501 | 6985 SF | 84   | 2817  | 63   | 8208  | 0 | 0 | 1744  | 12832  |
| 340010.0783105 | 6" BATT. INSUL.                 | 501 | 7030 SF | 49   | 1643  | 35   | 2956  | 0 | 0 | 898   | 5532   |

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FLUOR DANIEL INC.  
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SMF CARISTER STORAGE BUILDING  
CONCEPTUAL DESIGN ESTIMATE, JULY 21, 1995  
D1 - ESTIMATE DETAIL BY MBS

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| ACCOUNT<br>NUMBER               | DESCRIPTION                                         | COST<br>CODE | QUANTITY | MANHOURS | LABOR   | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | ONMP<br>/ B & I | TOTAL<br>DOLLARS |
|---------------------------------|-----------------------------------------------------|--------------|----------|----------|---------|----------------|----------|------------------|----------------|-----------------|------------------|
| 340010.0832001                  | 3 X 7 H M DOOR                                      | 501          | 13 EA    | 104      | 3173    | 226            | 7568     | 0                | 0              | 1865            | 12832            |
| 340010.0832018                  | 6 X 7 H M DOOR                                      | 501          | 6 PR     | 96       | 2813    | 75             | 8732     | 0                | 0              | 1776            | 13396            |
| 340010.0832019                  | ENTRENCE DOOR                                       | 501          | 2 EA     | 20       | 586     | 16             | 1887     | 0                | 0              | 375             | 2864             |
| 340010.0932004                  | 5/8 GYP BOARD<br>CEILING                            | 501          | 4810 SF  | 111      | 3252    | 87             | 1815     | 0                | 0              | 1516            | 6670             |
| 340010.0932005                  | SUSPENDED CEILING GRID                              | 501          | 4810 SF  | 139      | 4073    | 111            | 2334     | 0                | 0              | 1902            | 8420             |
| 340010.0932009                  | CERAMIC TILE                                        | 501          | 500 SF   | 45       | 1319    | 35             | 2307     | 0                | 0              | 717             | 4378             |
| 340010.0932015                  | SANITARY COVE                                       | 501          | 275 LF   | 55       | 1612    | 43             | 1171     | 0                | 0              | 769             | 3595             |
| 340010.0932016                  | 6" HIGH<br>FILLER                                   | 501          | 10 CF    | 45       | 1319    | 58             | 397      | 0                | 0              | 594             | 2368             |
| 340010.0932001                  | DRY WALL                                            | 501          | 14060 SF | 773      | 22649   | 605            | 15460    | 0                | 0              | 10738           | 49452            |
| 340010.0981023                  | PAINTING                                            | 501          | 45010 SF | 2701     | 71036   | 3466           | 26687    | 0                | 0              | 32364           | 133553           |
| 340010.0981024                  | SEALER/HARDNER                                      | 501          | 24570 SF | 344      | 9047    | 246            | 7946     | 0                | 0              | 4404            | 21643            |
| 340010.0981025                  | COAT FLOOR                                          | 501          | 1510 SF  | 195      | 5129    | 166            | 8888     | 0                | 0              | 2784            | 16967            |
| 340010.0981026                  | COAT CEILING/WALLS                                  | 501          | 8390 SF  | 906      | 23828   | 1175           | 13748    | 0                | 0              | 11169           | 49920            |
| 340010.0984006                  | SANDBLAST                                           | 501          | 3650 SF  | 234      | 6742    | 329            | 1574     | 0                | 0              | 3009            | 11654            |
| 340010.1540400                  | PLUMBING                                            | 501          | 6985 SF  | 175      | 6125    | 489            | 3765     | 0                | 0              | 2898            | 13277            |
| 340010.1662N52                  | GROUNDING                                           | 501          | 1 LOT    | 70       | 2450    | 158            | 1106     | 0                | 0              | 1131            | 4845             |
| 340010.1662N53                  | LIGHTNING PROTECTION                                | 501          | 1 LOT    | 135      | 4725    | 304            | 1359     | 0                | 0              | 2130            | 8518             |
| SUBTOTAL 340010 STRUCTURE       |                                                     |              | 11,324   |          | 326,648 | 37,272         | 354,661  | 0                | 0              | 165,284         | 883,865          |
| 340040                          | FIRE PROTECTION                                     |              |          |          |         |                |          |                  |                |                 |                  |
| 340040.1559001                  | SPRINKLER SYSTEM<br>(SF ALLOWANCE)                  | 501          | 6985 SF  | 419      | 13266   | 1132           | 8660     | 0                | 0              | 6315            | 29373            |
| SUBTOTAL 340040 FIRE PROTECTION |                                                     |              | 419      |          | 13,266  | 1,132          | 8,660    | 0                | 0              | 6,315           | 29,373           |
| 340050                          | HVAC                                                |              |          |          |         |                |          |                  |                |                 |                  |
| 340050.1528AA3                  | GALV DUCTING FOR PERSONNEL/<br>UTILITY/SUPPORT AREA | 700          | 1 LOT    | 840      | 26914   | 1378           | 14014    | 0                | 0              | 12520           | 54826            |
| 340050.1528AA6                  | COPPER TUBING                                       | 700          | 1 LOT    | 300      | 9612    | 492            | 3234     | 0                | 0              | 4356            | 17694            |
| 340050.1543AA4                  | EF-4<br>EXHAUST FAN<br>2000 CFM                     | 700          | 1 EA     | 20       | 713     | 193            | 0        | 0                | 0              | 318             | 1224             |
| 340050.1544AA3                  | ACC-3<br>AIR COOLED CONDENSING UNIT                 | 700          | 1 EA     | 20       | 713     | 193            | 0        | 0                | 0              | 318             | 1224             |
| 340050.1547AA4                  | ANU-5<br>AIR HANDLING UNIT                          | 700          | 1 EA     | 20       | 713     | 193            | 0        | 0                | 0              | 318             | 1224             |

FLUOR DANIEL INC.  
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| ACCOUNT<br>NUMBER    | DESCRIPTION                                                                                        | COST<br>CODE | QUANTITY | MANHOURS | LABOR   | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OH&P<br>/ B & I | TOTAL<br>DOLLARS |
|----------------------|----------------------------------------------------------------------------------------------------|--------------|----------|----------|---------|----------------|----------|------------------|----------------|-----------------|------------------|
| 340050.1662H60       | 2000 CFM<br>3 HP<br>HVAC ELECTRICAL                                                                | 700          | 1 LOT    | 813      | 26049   | 1829           | 25092    | 0                | 0              | 12899           | 65869            |
| 340050.1773AA6       | INSTRUMENTS FOR HVAC<br>EQUIPMENT                                                                  | 700          | 1 LOT    | 2500     | 87375   | 7250           | 43120    | 0                | 0              | 40671           | 178416           |
| 340050.1773AA7       | (125 PCS)<br>HVAC SC2 SHUTDOWN PANEL                                                               | 700          | 2 EA     | 160      | 5592    | 464            | 21560    | 0                | 0              | 3825            | 31441            |
| SUBTOTAL 340050 HVAC |                                                                                                    |              |          | 4,673    | 157,681 | 11,992         | 107,020  | 0                | 0              | 75,225          | 351,918          |
| 340320               | ELECTRICAL DISTRIBUTION                                                                            |              |          |          |         |                |          |                  |                |                 |                  |
| 340320.1661AA1       | XFMR #1<br>750KVA, 13.8-.48KV, 3 PHASE<br>4W, PAD MOUNTED, OIL FILLED<br>TRANSFORMER               | 600          | 1 EA     | 100      | 3420    | 368            | 0        | 0                | 0              | 1488            | 5276             |
| 340320.1661AA2       | SMGR #1<br>480V, 3 PHASE, 60 HZ, 1600 A<br>SWITCHGEAR                                              | 600          | 1 EA     | 100      | 3420    | 368            | 0        | 0                | 0              | 1488            | 5276             |
| 340320.1661AA3       | MCC #1 & #2<br>480V, 3 PHASE, 60 HZ, 300 A<br>MCC, TRIN A & B                                      | 600          | 2 EA     | 200      | 6840    | 736            | 0        | 0                | 0              | 2975            | 10551            |
| 340320.1661AA4       | MCC #3 & #4<br>480V, 3 PHASE, 60 HZ, 800 A<br>MCC, TRIN A & B                                      | 600          | 2 EA     | 200      | 6840    | 736            | 0        | 0                | 0              | 2975            | 10551            |
| 340320.1661AA5       | UPS #1 & #2<br>3 KVA, 120V, 1 PHASE, 3W, W/<br>BATTERIES 15 MIN UPS                                | 600          | 2 EA     | 200      | 6840    | 736            | 0        | 0                | 0              | 2975            | 10551            |
| 340320.1661AA6       | UPS #3<br>10 KVA, 208/120V, 3 PHASE, 4W,<br>W/BATTERIES 15 MIN UPS                                 | 600          | 1 EA     | 100      | 3420    | 368            | 0        | 0                | 0              | 1488            | 5276             |
| 340320.1661AA7       | PAN PRD #1 THRU #4<br>15 KVA, 12 CKT, 480-208/120V,<br>3 PHASE, 4W, PANEL BOARD,<br>FULLY EQUIPPED | 600          | 4 EA     | 400      | 13680   | 1472           | 0        | 0                | 0              | 5951            | 21103            |
| 340320.1661AA8       | ATS #1 & #2<br>300A, 480/277V,<br>3 PHASE, 4W, AUTOMATIC<br>TRANSFER SWITCH                        | 600          | 2 EA     | 200      | 6840    | 736            | 0        | 0                | 0              | 2975            | 10551            |
| 340320.1662H50       | AREA LIGHTING                                                                                      | 600          | 6985 SF  | 601      | 21035   | 1118           | 21535    | 0                | 0              | 10475           | 54163            |
| 340320.1662H61       | NORMAL ELECTRICAL DIST                                                                             | 600          | 1 LOT    | 366      | 11727   | 824            | 10141    | 0                | 0              | 5732            | 28424            |
| 340320.1662H62       | UPS                                                                                                | 600          | 1 LOT    | 119      | 3813    | 268            | 254      | 0                | 0              | 1666            | 6001             |

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| ACCOUNT<br>NUMBER | DESCRIPTION                                                         | COST<br>CODE | QUANTITY | MANHOURS | LABOR  | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | ON&P<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|---------------------------------------------------------------------|--------------|----------|----------|--------|----------------|----------|------------------|----------------|-----------------|------------------|
|                   |                                                                     |              |          | 2,586    | 87,875 | 7,730          | 31,930   | 0                | 0              | 40,188          | 167,723          |
| SUBTOTAL 340320   | ELECTRICAL DISTRIBUTION                                             |              |          |          |        |                |          |                  |                |                 |                  |
| 340410            | INSTRUMENT AIR                                                      |              |          |          |        |                |          |                  |                |                 |                  |
| 340410.1143AA1    | C-1A/B<br>AIR COMPRESSORS<br>BHP 25<br>(CS)                         | 700          | 2 EA     | 80       | 2624   | 773            | 0        | 0                | 0              | 1173            | 4570             |
| 340410.1143AA2    | DY-1<br>INSTRUMENT AIR DRYER<br>100 SCFM<br>(CS)                    | 700          | 1 EA     | 100      | 3280   | 966            | 0        | 0                | 0              | 1467            | 5713             |
| 340410.1143AA3    | V-1<br>INSTRUMENT AIR RECEIVER<br>8" DIA X 8' T/T<br>(CS)           | 700          | 1 EA     | 40       | 1312   | 386            | 0        | 0                | 0              | 587             | 2285             |
| 340410.1552AAC    | PIPE, 1", C S<br>SCH 80, FIELD FAB                                  | 700          | 100 LF   | 151      | 5277   | 438            | 524      | 0                | 0              | 2321            | 8560             |
| 340410.1552AAE    | PIPE, 2", C S<br>SCH 40, SHOP FAB, 150#                             | 700          | 200 LF   | 178      | 6221   | 516            | 3148     | 0                | 0              | 2901            | 12786            |
| 340410.1555AAC    | VA, 1", 150#, CS                                                    | 700          | 8 EA     | 50       | 1748   | 146            | 1311     | 0                | 0              | 843             | 4048             |
| 340410.1555AAE    | VA, 2", 150#, CS                                                    | 700          | 4 EA     | 32       | 1118   | 94             | 1319     | 0                | 0              | 570             | 3101             |
| 340410.1773AA3    | INSTRUMENTS FOR INSTRUMENT<br>AIR EQUIPMENT<br>(50 PCS)             | 700          | 1 LOT    | 1000     | 34950  | 2900           | 56056    | 0                | 0              | 18791           | 112697           |
| SUBTOTAL 340410   | INSTRUMENT AIR                                                      |              |          | 1,631    | 56,530 | 6,219          | 62,358   | 0                | 0              | 28,653          | 153,760          |
| 340480            | PROCESS WATER SYSTEM                                                |              |          |          |        |                |          |                  |                |                 |                  |
| 340480.1142AA7    | V-8<br>PROCESS WATER STORAGE TANK<br>7.5' DIA X 16' T/T<br>(304LSS) | 700          | 1 EA     | 40       | 1384   | 386            | 0        | 0                | 0              | 617             | 2387             |
| 340480.1146AA6    | P-7A/B<br>PROCESS WATER PUMPS<br>5 HP<br>(304LSS)                   | 700          | 2 EA     | 40       | 1312   | 386            | 0        | 0                | 0              | 587             | 2285             |
| 340480.1552BAC    | PIPE, 1", 304LSS<br>SCH 80, FIELD FAB, 150#                         | 700          | 200 LF   | 514      | 17964  | 1491           | 4942     | 0                | 0              | 8106            | 32503            |
| 340480.1552BAE    | PIPE, 2", 304LSS<br>SCH 40, SHOP FAB, 150#                          | 700          | 100 LF   | 124      | 4334   | 360            | 3168     | 0                | 0              | 2084            | 9946             |

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SNF CANISTER STORAGE BUILDING  
CONCEPTUAL DESIGN ESTIMATE, JULY 21, 1995  
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| ACCOUNT<br>NUMBER | DESCRIPTION                                                                 | COST<br>CODE | QUANTITY | MANHOURS | LABOR  | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OH&P<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|-----------------------------------------------------------------------------|--------------|----------|----------|--------|----------------|----------|------------------|----------------|-----------------|------------------|
| 340480.1555BAC    | VA, 1", 150#, 304LSS                                                        | 700          | 8 EA     | 86       | 3006   | 251            | 1828     | 0                | 0              | 1422            | 6507             |
| 340480.1555BAE    | VA, 2", 150#, 304LSS                                                        | 700          | 4 EA     | 54       | 1887   | 157            | 1617     | 0                | 0              | 923             | 4584             |
| 340480.1773AA1    | INSTRUMENTS FOR PROCESS<br>WATER EQUIPMENT<br>(15 PCS)                      | 700          | 1 LOT    | 300      | 10485  | 879            | 12936    | 0                | 0              | 5386            | 29686            |
| -----             |                                                                             |              |          |          |        |                |          |                  |                |                 |                  |
| SUBTOTAL 340480   | PROCESS WATER SYSTEM                                                        |              |          | 1,158    | 40,372 | 3,910          | 24,491   | 0                | 0              | 19,125          | 87,898           |
| -----             |                                                                             |              |          |          |        |                |          |                  |                |                 |                  |
| 340490            | SANITARY WATER SYSTEM                                                       |              |          |          |        |                |          |                  |                |                 |                  |
| 340490.1552AAC    | PIPE, 1", C S                                                               | 700          | 100 LF   | 151      | 5277   | 438            | 524      | 0                | 0              | 2321            | 8560             |
| 340490.1552AAF    | SCH 80, FIELD FAB<br>PIPE, 3", C S                                          | 700          | 300 LF   | 345      | 12058  | 1001           | 8929     | 0                | 0              | 5806            | 27794            |
| 340490.1555AAC    | SCH 40, SHOP FAB, 150#<br>VA, 1", 150#, CS                                  | 700          | 8 EA     | 50       | 1748   | 146            | 1311     | 0                | 0              | 843             | 4048             |
| 340490.1555AAF    | VA, 3", 150#, CS                                                            | 700          | 6 EA     | 67       | 2342   | 195            | 2962     | 0                | 0              | 1208            | 6707             |
| -----             |                                                                             |              |          |          |        |                |          |                  |                |                 |                  |
| SUBTOTAL 340490   | SANITARY WATER SYSTEM                                                       |              |          | 613      | 21,425 | 1,780          | 13,726   | 0                | 0              | 10,178          | 47,109           |
| -----             |                                                                             |              |          |          |        |                |          |                  |                |                 |                  |
| 340530            | LIQUID WASTE COLLECTION SYSTEM                                              |              |          |          |        |                |          |                  |                |                 |                  |
| 340530.1142AA5    | V-6<br>WASTE WASHWATER HOLD TANK<br>6" DIA X 10' T/T<br>(CS W/EPOXY LINING) | 700          | 1 EA     | 20       | 692    | 193            | 0        | 0                | 0              | 309             | 1194             |
| 340530.1146AA4    | P-4<br>WASTE WASHWATER SUMP PUMP<br>5 HP<br>(304LSS)                        | 700          | 1 EA     | 20       | 656    | 193            | 0        | 0                | 0              | 293             | 1142             |
| 340530.1552AAE    | PIPE, 2", C S                                                               | 700          | 100 LF   | 89       | 3111   | 258            | 1574     | 0                | 0              | 1450            | 6393             |
| 340530.1555AAE    | SCH 40, SHOP FAB, 150#<br>VA, 2", 150#, CS                                  | 700          | 4 EA     | 32       | 1118   | 94             | 1319     | 0                | 0              | 570             | 3101             |
| 340530.1773AA2    | INSTRUMENTS FOR WASTE<br>WATER EQUIPMENT<br>(15 PCS)                        | 700          | 1 LOT    | 1000     | 34950  | 2900           | 15092    | 0                | 0              | 16128           | 69070            |
| -----             |                                                                             |              |          |          |        |                |          |                  |                |                 |                  |
| SUBTOTAL 340530   | LIQUID WASTE COLLECTION SYS                                                 |              |          | 1,161    | 40,527 | 3,638          | 17,985   | 0                | 0              | 18,750          | 80,900           |
| -----             |                                                                             |              |          |          |        |                |          |                  |                |                 |                  |
| 340610            | DCS                                                                         |              |          |          |        |                |          |                  |                |                 |                  |
| 340610.1771AA1    | DCS                                                                         | 700          | 1 LOT    | 400      | 13680  | 1472           | 0        | 0                | 0              | 5951            | 21103            |
| -----             |                                                                             |              |          |          |        |                |          |                  |                |                 |                  |
| SUBTOTAL 340610   | DCS                                                                         |              |          | 400      | 13,680 | 1,472          | 0        | 0                | 0              | 5,951           | 21,103           |

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FLUOR DANIEL INC.  
WESTINGHOUSE HANFORD COMPANY  
JOB NO. 04436307

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| ACCOUNT<br>NUMBER                        | DESCRIPTION                                                  | COST<br>CODE | QUANTITY | MANHOURS | LABOR   | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OH&P<br>/ B & I | TOTAL<br>DOLLARS |
|------------------------------------------|--------------------------------------------------------------|--------------|----------|----------|---------|----------------|----------|------------------|----------------|-----------------|------------------|
| 340620                                   | HEALTH PHYSICS SYSTEM                                        |              |          |          |         |                |          |                  |                |                 |                  |
| 340620.1143AA4                           | MB-1A/B<br>VAVUUM SYSTEM BLOWERS<br>(CS)                     | 700          | 2 EA     | 200      | 6560    | 1932           | 0        | 0                | 0              | 2933            | 11425            |
| 340620.1147A19                           | F-3A/B<br>VACUUM SYSTEM HEPA FILTERS<br>100 ACFM<br>(304LSS) | 700          | 2 EA     | 40       | 1312    | 386            | 0        | 0                | 0              | 587             | 2285             |
| 340620.1552111                           | ALLOWANCE FOR VACUUM SYSTEM<br>PIPING                        | 700          | 1 LOT    | 320      | 11184   | 935            | 22315    | 0                | 0              | 6298            | 40732            |
| 340620.1662111                           | ALLOWANCE FOR VACUUM SYSTEM<br>ELECTRICAL                    | 700          | 1 LOT    | 1240     | 42408   | 4600           | 18542    | 0                | 0              | 19655           | 85205            |
| 340620.1771AA2                           | HPS, HARDWARE INSTALLATION                                   | 700          | 1 LOT    | 2000     | 68400   | 18400          | 0        | 0                | 0              | 30471           | 117271           |
| 340620.1773AA4                           | INSTRUMENTS FOR HP<br>EQUIPMENT<br>(20 PCS)                  | 700          | 1 LOT    | 400      | 13980   | 1160           | 17248    | 0                | 0              | 7180            | 39568            |
| -----                                    |                                                              |              |          |          |         |                |          |                  |                |                 |                  |
| SUBTOTAL 340620 HEALTH PHYSICS SYSTEM    |                                                              |              |          | 4,200    | 143,844 | 27,413         | 58,105   | 0                | 0              | 67,124          | 296,486          |
| 340650                                   | COMMUNICATIONS                                               |              |          |          |         |                |          |                  |                |                 |                  |
| 340650.1662H51                           | COMMUNICATION                                                | 501          | 6985 SF  | 286      | 10010   | 210            | 2334     | 0                | 0              | 4450            | 17004            |
| -----                                    |                                                              |              |          |          |         |                |          |                  |                |                 |                  |
| SUBTOTAL 340650 COMMUNICATIONS           |                                                              |              |          | 286      | 10,010  | 210            | 2,334    | 0                | 0              | 4,450           | 17,004           |
| 340720                                   | COLD HANDLING EQUIPMENT                                      |              |          |          |         |                |          |                  |                |                 |                  |
| 340720.1147A29                           | SN-1<br>SHOP EQUIPMENT                                       | 755          | 1 LOT    | 80       | 2624    | 773            | 0        | 0                | 0              | 1173            | 4570             |
| 340720.1335AA9                           | SD-5A/B<br>SHIELD DOOR, PERSONNEL(DBL)<br>(5"X6'X7')         | 700          | 2 EA     | 200      | 6234    | 1022           | 0        | 0                | 0              | 2735            | 9991             |
| -----                                    |                                                              |              |          |          |         |                |          |                  |                |                 |                  |
| SUBTOTAL 340720 COLD HANDLING EQUIPMENT  |                                                              |              |          | 280      | 8,858   | 1,795          | 0        | 0                | 0              | 3,908           | 14,561           |
| -----                                    |                                                              |              |          |          |         |                |          |                  |                |                 |                  |
| SUBTOTAL 340 PERSONNEL/UTILITY/SUPPORT A |                                                              |              |          | 28,731   | 920,716 | 104,563        | 681,270  | 0                | 0              | 445,151         | 2,151,700        |
| 360010                                   | STRUCTURE                                                    |              |          |          |         |                |          |                  |                |                 |                  |
| 360010.0202001                           | MACHINE EXCAVATION                                           | 501          | 1755 CY  | 123      | 3512    | 5416           | 0        | 0                | 0              | 1855            | 10783            |

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| ACCOUNT<br>NUMBER               | DESCRIPTION                            | COST<br>CODE | QUANTITY | MANHOURS | LABOR  | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | ONEP<br>/ B & I | TOTAL<br>DOLLARS |
|---------------------------------|----------------------------------------|--------------|----------|----------|--------|----------------|----------|------------------|----------------|-----------------|------------------|
| 360010.0202101                  | HAND EXCAVATION                        | 501          | 20 CY    | 20       | 530    | 0              | 0        | 0                | 0              | 227             | 757              |
| 360010.0311001                  | SPREAD FOOTINGS                        | 501          | 190 CY   | 1520     | 44946  | 4256           | 25398    | 0                | 0              | 21164           | 95764            |
| 360010.0312001                  | FOUNDATION                             | 501          | 205 CY   | 1845     | 54557  | 5167           | 34474    | 0                | 0              | 25927           | 120125           |
| 360010.0313001                  | SLAB ON GRADE, < 12"                   | 501          | 175 CY   | 875      | 25874  | 2450           | 22449    | 0                | 0              | 12693           | 63466            |
| 360010.0313A10                  | SLAB ON GRADE, > 36"                   | 501          | 40 CY    | 240      | 7097   | 672            | 5174     | 0                | 0              | 3417            | 16360            |
| 360010.0315A05                  | WALLS, 12"-36"                         | 501          | 155 CY   | 2636     | 77947  | 7381           | 28739    | 0                | 0              | 35709           | 149776           |
| 360010.0319901                  | WASTE AND SPILLAGE                     | 501          | 15 CY    | 22       | 651    | 63             | 889      | 0                | 0              | 340             | 1943             |
| 360010.0525AAA                  | STRUCTURAL STEEL,LT., MED.,            | 501          | 23 TON   | 575      | 18101  | 5555           | 56034    | 0                | 0              | 11751           | 91441            |
| 360010.0525AAB                  | HVY & OTHER MISC STEEL                 | 501          | 11 TON   | 253      | 7964   | 2443           | 27036    | 0                | 0              | 5325            | 42768            |
| 360010.0525AAC                  | STRUCTURAL STEEL,LT.                   | 501          | 44 TON   | 836      | 26317  | 8081           | 74943    | 0                | 0              | 16660           | 126001           |
| 360010.0525AAD                  | STRUCTURAL STEEL,HVY                   | 501          | 73 TON   | 1168     | 36769  | 11283          | 99154    | 0                | 0              | 22915           | 170121           |
| 360010.0525AAF                  | STRUCTURAL STEEL,LADDERS               | 501          | 1 TON    | 60       | 1889   | 578            | 4635     | 0                | 0              | 1148            | 8250             |
| 360010.0525AAK                  | W/CAGE                                 | 501          | 9257 SF  | 231      | 7272   | 2240           | 12873    | 0                | 0              | 4095            | 26480            |
| 360010.0525AAL                  | STRUCTURAL STEEL, METAL                | 501          | 158 SF   | 32       | 1007   | 305            | 1616     | 0                | 0              | 556             | 3484             |
| 360010.0731001                  | DECK                                   | 501          | 9260 SF  | 148      | 3744   | 139            | 13676    | 0                | 0              | 2500            | 20059            |
| 360010.0783101                  | MEMBRANE ROOFING                       | 501          | 9260 SF  | 111      | 3722   | 83             | 10880    | 0                | 0              | 2305            | 16990            |
| 360010.0783102                  | ROOF INSULATION                        | 501          | 3630 SF  | 399      | 12173  | 868            | 20153    | 0                | 0              | 6577            | 39771            |
| 360010.0832001                  | INSULATED SIDING                       | 501          | 11 EA    | 88       | 2685   | 191            | 6403     | 0                | 0              | 1578            | 10857            |
| 360010.0832018                  | 3 X 7 M N DOOR                         | 501          | 3 PR     | 48       | 1406   | 37             | 4366     | 0                | 0              | 888             | 6697             |
| 360010.0981023                  | 6 X7 H M DOOR                          | 501          | 77525 SF | 4652     | 122348 | 5969           | 45965    | 0                | 0              | 55740           | 230022           |
| 360010.0981024                  | PAINTING                               | 501          | 25585 SF | 358      | 9415   | 256            | 8275     | 0                | 0              | 4584            | 22530            |
| 360010.0981024                  | SEALER/HARDNER                         | 501          | 1 LOT    | 100      | 3500   | 225            | 1584     | 0                | 0              | 1615            | 6924             |
| 360010.1662H52                  | GROUNDING                              | 501          | 1 LOT    | 197      | 6895   | 443            | 1947     | 0                | 0              | 3106            | 12391            |
| 360010.1662H53                  | LIGHTNING PROTECTION                   | 501          | 1 LOT    | 197      | 6895   | 443            | 1947     | 0                | 0              | 3106            | 12391            |
| SUBTOTAL 360010 STRUCTURE       |                                        |              | 16,537   | 480,321  | 64,101 | 506,663        | 0        | 0                | 242,675        | 1,293,760       |                  |
| 360040                          | FIRE PROTECTION                        |              |          |          |        |                |          |                  |                |                 |                  |
| 360040.1559001                  | SPRINKLER SYSTEM<br>(SF ALLOWANCE)     | 501          | 9260 SF  | 556      | 17603  | 1500           | 11480    | 0                | 0              | 8378            | 38961            |
| SUBTOTAL 360040 FIRE PROTECTION |                                        |              | 556      | 17,603   | 1,500  | 11,480         | 0        | 0                | 8,378          | 38,961          |                  |
| 360050                          | HVAC                                   |              |          |          |        |                |          |                  |                |                 |                  |
| 360050.1528AAA                  | GALV DUCTING FOR HVAC EQUIP            | 700          | 1 LOT    | 1020     | 32681  | 0              | 17248    | 0                | 0              | 15108           | 65037            |
| 360050.1540AAA1                 | AREA<br>PP-1A/B<br>HEPA FILTER PLENUMS | 700          | 2 EA     | 600      | 21402  | 5855           | 0        | 0                | 0              | 9541            | 36798            |

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| ACCOUNT<br>NUMBER | DESCRIPTION                                             | COST<br>CODE | QUANTITY | MANHOURS | LABOR | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | ON&P<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|---------------------------------------------------------|--------------|----------|----------|-------|----------------|----------|------------------|----------------|-----------------|------------------|
| 360050.1540AA2    | 6000 CFM<br>PF-2A/B<br>HEPA FILTER PLENUMS<br>12000 CFM | 700          | 2 EA     | 1000     | 35670 | 9660           | 0        | 0                | 0              | 15895           | 61225            |
| 360050.1540AA3    | PF-3A/B<br>HEPA FILTER PLENUMS<br>4000 CFM              | 700          | 2 EA     | 400      | 14268 | 3864           | 0        | 0                | 0              | 6358            | 24490            |
| 360050.1543AA1    | EF-1A/B<br>EMERGENCY EXHAUST FANS<br>6000 CFM<br>15 HP  | 700          | 2 EA     | 40       | 1427  | 386            | 0        | 0                | 0              | 636             | 2449             |
| 360050.1543AA2    | EF-2A/B<br>RECIRC/EXHAUST FANS<br>12000 CFM<br>25 HP    | 700          | 2 EA     | 40       | 1427  | 386            | 0        | 0                | 0              | 636             | 2449             |
| 360050.1543AA3    | EF-3A/B<br>EXHAUST FANS<br>4000 CFM<br>10 HP            | 700          | 2 EA     | 40       | 1427  | 386            | 0        | 0                | 0              | 636             | 2449             |
| 360050.1543AA5    | SF-1A/B<br>SUPPLY FANS<br>20000 CFM<br>10 HP            | 700          | 2 EA     | 40       | 1427  | 386            | 0        | 0                | 0              | 636             | 2449             |
| 360050.1544AA1    | ACC-1/2<br>AIR COOLED CONDENSING UNITS<br>50 KW         | 700          | 2 EA     | 160      | 5707  | 1546           | 0        | 0                | 0              | 2543            | 9796             |
| 360050.1544AA4    | EH-5 THRU 8<br>ELECTRIC UNIT HEATERS<br>10 KW           | 700          | 4 EA     | 40       | 1427  | 386            | 0        | 0                | 0              | 636             | 2449             |
| 360050.1547AA1    | AHU-1/2<br>AIR WASHERS<br>20000 CFM<br>30 HP            | 700          | 2 EA     | 120      | 4280  | 1157           | 0        | 0                | 0              | 1907            | 7344             |
| 360050.1547AA2    | AHU-3<br>Kr OSA PURGE<br>9000 CFM<br>7.5 HP             | 700          | 1 EA     | 350      | 12485 | 3331           | 0        | 0                | 0              | 5560            | 21376            |
| 360050.1547AA3    | AHU-4A/B<br>AIR HANDLING UNITS<br>11000 CFM<br>15 HP    | 700          | 2 EA     | 80       | 2854  | 773            | 0        | 0                | 0              | 1272            | 4899             |
| 360050.1662H60    | HVAC ELECTRICAL                                         | 501          | 1 LOT    | 1046     | 33514 | 2354           | 32259    | 0                | 0              | 16594           | 84721            |

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| ACCOUNT<br>NUMBER                       | DESCRIPTION                | COST<br>CODE | QUANTITY  | MANHOURS | LABOR   | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OH&P<br>/ B & I | TOTAL<br>DOLLARS |
|-----------------------------------------|----------------------------|--------------|-----------|----------|---------|----------------|----------|------------------|----------------|-----------------|------------------|
| SUBTOTAL 360050 HVAC                    |                            |              |           | 4,976    | 169,996 | 30,470         | 49,507   | 0                | 0              | 77,958          | 327,931          |
| 360320                                  | ELECTRICAL DISTRIBUTION    |              |           |          |         |                |          |                  |                |                 |                  |
| 360320.1662H50                          | AREA LIGHTING              | 501          | 9260 SF   | 796      | 27860   | 1482           | 28550    | 0                | 0              | 13876           | 71768            |
| 360320.1662H61                          | NORMAL ELECTRICAL DIST     | 501          | 1 LOT     | 470      | 15059   | 1058           | 13037    | 0                | 0              | 7361            | 36515            |
| SUBTOTAL 360320 ELECTRICAL DISTRIBUTION |                            |              |           | 1,266    | 42,919  | 2,540          | 41,587   | 0                | 0              | 21,237          | 108,283          |
| 360650                                  | COMMUNICATIONS             |              |           |          |         |                |          |                  |                |                 |                  |
| 360650.1662H51                          | COMMUNICATION              | 501          | 9260 SF   | 380      | 13300   | 0              | 3095     | 0                | 0              | 5894            | 22289            |
| SUBTOTAL 360650 COMMUNICATIONS          |                            |              |           | 380      | 13,300  | 0              | 3,095    | 0                | 0              | 5,894           | 22,289           |
| SUBTOTAL 360                            | HVAC EQUIPMENT AREA        |              |           | 23,715   | 724,139 | 98,611         | 612,332  | 0                | 0              | 356,142         | 1,791,224        |
| 370010                                  | SITE                       |              |           |          |         |                |          |                  |                |                 |                  |
| 370010.0191001                          | EARTH BERM, RADIATION      | 460          | 7100 CY   | 1065     | 31950   | 26625          | 0        | 0                | 0              | 15405           | 73980            |
|                                         | BARRIER                    |              |           |          |         |                |          |                  |                |                 |                  |
| 370010.0191005                          | SWITCHES, RAILROAD         | 460          | 5 EA      | 480      | 14400   | 931            | 78155    | 0                | 0              | 11304           | 104790           |
| 370010.0191011                          | ROADS - 3" A/C PAVING      | 460          | 3770 SY   | 143      | 4108    | 3336           | 36748    | 0                | 0              | 4233            | 46425            |
|                                         | W/2" LEVEL COURSE,         |              |           |          |         |                |          |                  |                |                 |                  |
|                                         | 4" BASE COURSE-32' WIDE    |              |           |          |         |                |          |                  |                |                 |                  |
| 370010.0191035                          | WAREHOUSE SECURITY FENCE   | 460          | 2280 LF   | 296      | 8688    | 1819           | 20154    | 0                | 0              | 5147            | 35808            |
|                                         | (7' CHAIN LINK, W/3 LINES  |              |           |          |         |                |          |                  |                |                 |                  |
|                                         | BARBED WIRE)               |              |           |          |         |                |          |                  |                |                 |                  |
| 370010.0191039                          | INSTALL 24' WIDE           | 460          | 6 EA      | 186      | 5459    | 1141           | 4140     | 0                | 0              | 2679            | 13419            |
|                                         | DOUBLE SWING GATES         |              |           |          |         |                |          |                  |                |                 |                  |
| 370010.0191052                          | SINGLE TRACK RAILROAD SPUR | 460          | 3370 LF   | 3370     | 92001   | 6538           | 171399   | 0                | 0              | 50942           | 320880           |
|                                         | INCL WOOD TIES & BALLAST   |              |           |          |         |                |          |                  |                |                 |                  |
| 370010.0201036                          | REALIGN EXISTING FENCE     | 460          | 50 LF     | 8        | 228     | 32             | 0        | 0                | 0              | 100             | 360              |
| 370010.0202001                          | MACHINE EXCAVATION         | 460          | 11705 CY  | 819      | 23382   | 36122          | 0        | 0                | 0              | 12355           | 71859            |
| 370010.0202100                          | LEADWALLS                  | 460          | 2 EA      | 44       | 1201    | 6              | 640      | 0                | 0              | 556             | 2403             |
| 370010.0203001                          | MACHINE BACKFILL           | 460          | 137670 CY | 9637     | 275136  | 72965          | 0        | 0                | 0              | 122501          | 470602           |
| 370010.0203101                          | HAND BACKFILL              | 460          | 1335 CY   | 801      | 21210   | 0              | 0        | 0                | 0              | 9078            | 30288            |
| 370010.0203301                          | SAND BEDDING               | 460          | 240 CY    | 96       | 2591    | 192            | 828      | 0                | 0              | 1175            | 4786             |

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|----------------------|------------------------------------|--------------|----------|----------|---------|----------------|----------|------------------|----------------|-----------------|------------------|
| 370010.0203401       | LIGHT POLE FOUNDATION              | 460          | 4 CY     | 16       | 480     | 36             | 367      | 0                | 0              | 232             | 1115             |
| 370010.0205005       | EARTH BARRICADE                    | 460          | 150 CY   | 50       | 1365    | 96             | 0        | 0                | 0              | 590             | 2051             |
| 370010.0207001       | HAUL CRUSHED ROCK                  | 460          | 1325 CY  | 60       | 1756    | 1670           | 0        | 0                | 0              | 860             | 4286             |
| 370010.0208001       | SPREAD CRUSHED ROCK                | 460          | 11698 SY | 550      | 15802   | 14623          | 0        | 0                | 0              | 7714            | 38139            |
| 370010.0209114       | 36" CORRUGATED METAL<br>PIPE       | 460          | 300 LF   | 84       | 2860    | 190            | 10109    | 0                | 0              | 1894            | 15053            |
| 370010.0209503       | FIRE HYDRANTS, POST TYPE           | 460          | 1 EA     | 5        | 173     | 12             | 1159     | 0                | 0              | 150             | 1494             |
| 370010.02326E1       | AUGER HOLES FOR<br>LIGHT POLES     | 460          | 13 EA    | 130      | 3609    | 2146           | 0        | 0                | 0              | 1684            | 7439             |
| 370010.03310E1       | DUCTBANK FOR COMM.<br>AND POWER    | 460          | 321 CY   | 963      | 28476   | 2697           | 24223    | 0                | 0              | 13938           | 69334            |
| 370010.1557001       | SANITARY SEWER LINE<br>(4" FRP)    | 460          | 100 LF   | 35       | 1225    | 94             | 347      | 0                | 0              | 553             | 2219             |
| 370010.1557002       | FIRE WATER LINE<br>(8" FRP)        | 460          | 240 LF   | 168      | 5880    | 454            | 1759     | 0                | 0              | 2660            | 10753            |
| 370010.1557003       | CLEAN DRAIN LINE<br>(4" FRP)       | 460          | 1550 LF  | 543      | 19005   | 1457           | 5380     | 0                | 0              | 8578            | 34420            |
| 370010.1662C06       | 2" PVC SCH 80 CONDUIT, U/G         | 460          | 14350 LF | 1335     | 45457   | 3014           | 14078    | 0                | 0              | 20366           | 83115            |
| 370010.1662C26       | 2" RSG CONDUIT, U/G                | 460          | 3000 LF  | 297      | 10113   | 672            | 6856     | 0                | 0              | 4817            | 22458            |
| 370010.1662H41       | 3/C #2 W/GRD XHHW 600V DB          | 460          | 1570 LF  | 44       | 1498    | 99             | 9664     | 0                | 0              | 1275            | 12536            |
| 370010.1662H42       | REMOVE 3 EXISTING LIGHT<br>POLES   | 460          | 3 EA     | 24       | 816     | 54             | 0        | 0                | 0              | 353             | 1223             |
| 370010.1662H43       | SECURITY LIGHTS                    | 460          | 13 EA    | 282      | 9588    | 226            | 25085    | 0                | 0              | 5749            | 40648            |
| 370010.1662H44       | 30 PR #22 AVG                      | 460          | 2470 LF  | 136      | 4624    | 296            | 8600     | 0                | 0              | 2557            | 16077            |
| 370010.1662H45       | 50 PR #22 AVG                      | 460          | 2470 LF  | 170      | 5780    | 395            | 11795    | 0                | 0              | 3266            | 21236            |
| 370010.1662H46       | 6 PR #22 AVG                       | 460          | 2470 LF  | 25       | 850     | 49             | 2023     | 0                | 0              | 499             | 3421             |
| 370010.1662H47       | 15KV 3#2 AVG                       | 460          | 1650 LF  | 132      | 4488    | 297            | 20651    | 0                | 0              | 3282            | 28718            |
| 370010.1662H48       | 4-#500 MCH                         | 460          | 2640 LF  | 185      | 6290    | 422            | 20548    | 0                | 0              | 4056            | 31316            |
| 370010.1662H49       | ELECTRICAL MANHOLES                | 460          | 13 EA    | 325      | 11050   | 878            | 18611    | 0                | 0              | 5997            | 36536            |
| 370010.1662H57       | GROUNDING<br>(2/O CU WIRE)         | 460          | 1425 LF  | 98       | 3332    | 214            | 2274     | 0                | 0              | 1588            | 7408             |
| 370010.1662H58       | 10 PR #22 AVG                      | 460          | 2475 LF  | 64       | 2176    | 149            | 3308     | 0                | 0              | 1156            | 6789             |
| 370010.1662H59       | 1/C #12 AVG                        | 460          | 660 LF   | 4        | 136     | 7              | 51       | 0                | 0              | 62              | 256              |
| 370010.1662M44       | 3/C #8 W/GRD XHHW 600V DB          | 460          | 880 LF   | 11       | 375     | 24             | 1370     | 0                | 0              | 251             | 2020             |
| SUBTOTAL 370010 SITE |                                    |              |          | 22,681   | 667,558 | 179,978        | 498,322  | 0                | 0              | 329,802         | 1,675,660        |
| 370520               | DRAIN LINES                        |              |          |          |         |                |          |                  |                |                 |                  |
| 370520.1146AA7       | P-8A/B<br>DRAIN LINE PUMPS<br>5 HP | 700          | 2 EA     | 40       | 1312    | 386            | 0        | 0                | 0              | 587             | 2285             |

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FLUOR DANIEL INC.  
WESTINGHOUSE HANFORD COMPANY  
JOB NO. 04436307

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SNF CANISTER STORAGE BUILDING  
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| ACCOUNT<br>NUMBER                | DESCRIPTION                                      | COST<br>CODE | QUANTITY | MANHOURS | LABOR   | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OH&P<br>/ B & I | TOTAL<br>DOLLARS |
|----------------------------------|--------------------------------------------------|--------------|----------|----------|---------|----------------|----------|------------------|----------------|-----------------|------------------|
| (CS)                             |                                                  |              |          |          |         |                |          |                  |                |                 |                  |
| SUBTOTAL 370520 DRAIN LINES      |                                                  |              |          | 40       | 1,312   | 386            | 0        | 0                | 0              | 587             | 2,285            |
| SUBTOTAL 370 INFRASTRUCTURE      |                                                  |              |          | 22,721   | 668,870 | 180,364        | 498,322  | 0                | 0              | 330,389         | 1,677,945        |
| STRUCTURES                       |                                                  |              |          |          |         |                |          |                  |                |                 |                  |
| 380010                           | 380010.0202001 MACHINE EXCAVATION                | 501          | 94 CY    | 7        | 200     | 290            | 0        | 0                | 0              | 104             | 594              |
| 380010                           | 380010.0202101 HAND EXCAVATION                   | 501          | 1 CY     | 1        | 26      | 0              | 0        | 0                | 0              | 11              | 37               |
| 380010                           | 380010.0313A10 SLAB ON GRADE, > 36"              | 501          | 75 CY    | 450      | 13307   | 1260           | 9702     | 0                | 0              | 6408            | 30677            |
| 380010                           | 380010.0319901 WASTE AND SPILLAGE                | 501          | 2 CY     | 3        | 89      | 8              | 119      | 0                | 0              | 47              | 263              |
| 380010                           | 380010.0525AAB STRUCTURAL STEEL, LT.             | 501          | 7 TON    | 161      | 5068    | 1554           | 17205    | 0                | 0              | 3389            | 27216            |
| 380010                           | 380010.0731001 MEMBRANE ROOFING                  | 501          | 1355 SF  | 22       | 557     | 20             | 2001     | 0                | 0              | 369             | 2947             |
| 380010                           | 380010.0731001 METAL ROOFING                     | 501          | 1355 SF  | 46       | 1210    | 41             | 1416     | 0                | 0              | 613             | 3280             |
| 380010                           | 380010.0783100 ROOF INSULATION                   | 501          | 4160 SF  | 16       | 536     | 12             | 1592     | 0                | 0              | 333             | 2473             |
| 380010                           | 380010.0783101 INSULATED SIDING                  | 501          | 2 PR     | 458      | 13974   | 994            | 23095    | 0                | 0              | 7547            | 45610            |
| 380010                           | 380010.0832009 6 X 8 H DOOR                      | 501          | 7275 SF  | 32       | 976     | 69             | 4657     | 0                | 0              | 725             | 6427             |
| 380010                           | 380010.0981023 PAINTING                          | 501          | 1355 SF  | 437      | 11493   | 560            | 4313     | 0                | 0              | 5235            | 21601            |
| 380010                           | 380010.0981024 SEALER/HARDNER                    | 501          | 1 LOT    | 19       | 500     | 14             | 439      | 0                | 0              | 243             | 1196             |
| 380010                           | 380010.1662H52 GROUNDING                         | 501          | 1 LOT    | 15       | 525     | 34             | 226      | 0                | 0              | 242             | 1027             |
| 380010                           | 380010.1662H53 LIGHTNING PROTECTION              | 501          | 1 LOT    | 28       | 980     | 63             | 278      | 0                | 0              | 441             | 1762             |
| SUBTOTAL 380010 STRUCTURES       |                                                  |              |          | 1,695    | 49,441  | 4,919          | 65,043   | 0                | 0              | 25,707          | 145,110          |
| SPRINKLER SYSTEM                 |                                                  |              |          |          |         |                |          |                  |                |                 |                  |
| 380040                           | 380040.1559001 SPRINKLER SYSTEM (SF ALLOWANCE)   | 501          | 1455 SF  | 87       | 2754    | 236            | 1803     | 0                | 0              | 1311            | 6104             |
| SUBTOTAL 380040 SPRINKLER SYSTEM |                                                  |              |          | 87       | 2,754   | 236            | 1,803    | 0                | 0              | 1,311           | 6,104            |
| HVAC                             |                                                  |              |          |          |         |                |          |                  |                |                 |                  |
| 380050                           | 380050.1662H60 HVAC ELECTRICAL                   | 501          | 1 LOT    | 157      | 5030    | 353            | 4832     | 0                | 0              | 2490            | 12705            |
| SUBTOTAL 380050 HVAC             |                                                  |              |          | 157      | 5,030   | 353            | 4,832    | 0                | 0              | 2,490           | 12,705           |
| ELECTRICAL DISTRIBUTION          |                                                  |              |          |          |         |                |          |                  |                |                 |                  |
| 380320                           | 380320.1661AA9 EG-1/2 EMERGENCY GENERATORS(80KW) | 600          | 2 EA     | 1200     | 41040   | 4329           | 0        | 0                | 0              | 17847           | 63216            |

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| ACCOUNT<br>NUMBER                       | DESCRIPTION                                               | COST<br>CODE | QUANTITY | MANHOURS | LABOR   | EQUIP<br>USAGE | MATERIAL | SUB-<br>CONTRACT | EQUIP-<br>MENT | OH&P<br>/ 8 & 1 | TOTAL<br>DOLLARS |
|-----------------------------------------|-----------------------------------------------------------|--------------|----------|----------|---------|----------------|----------|------------------|----------------|-----------------|------------------|
| INCLUDING ALL ASSOCIATED<br>EQUIPMENT   |                                                           |              |          |          |         |                |          |                  |                |                 |                  |
| 380320.1662H50                          | AREA LIGHTING                                             | 501          | 1355 SF  | 117      | 4095    | 217            | 4177     | 0                | 0              | 2039            | 10528            |
| 380320.1662H61                          | NORMAL ELECTRICAL DIST                                    | 600          | 1 LOT    | 70       | 2243    | 158            | 1952     | 0                | 0              | 1097            | 5450             |
| 380320.1773AA5                          | INSTRUMENTS FOR POWER<br>GENERATION EQUIPMENT<br>(10 PCS) | 600          | 1 LOT    | 200      | 6990    | 580            | 8624     | 0                | 0              | 3590            | 19784            |
| 380320.1773AA8                          | SC2 GENERATOR PANEL                                       | 600          | 1 EA     | 80       | 2796    | 232            | 10780    | 0                | 0              | 1913            | 15721            |
| SUBTOTAL 380320 ELECTRICAL DISTRIBUTION |                                                           |              |          | 1,667    | 57,164  | 5,516          | 25,533   | 0                | 0              | 26,486          | 114,699          |
| 380650 COMMUNICATIONS                   |                                                           |              |          |          |         |                |          |                  |                |                 |                  |
| 380650.1662H51                          | COMMUNICATION                                             | 501          | 1355 SF  | 56       | 1960    | 41             | 453      | 0                | 0              | 871             | 3325             |
| SUBTOTAL 380650 COMMUNICATIONS          |                                                           |              |          | 56       | 1,960   | 41             | 453      | 0                | 0              | 871             | 3,325            |
| SUBTOTAL 380 POWER GENERATION           |                                                           |              |          | 3,662    | 116,349 | 11,065         | 97,664   | 0                | 0              | 56,865          | 281,943          |
| 385010 STRUCTURES                       |                                                           |              |          |          |         |                |          |                  |                |                 |                  |
| 385010.1333001                          | SAMPLING BLDG<br>(15'X15')                                | 501          | 125 SF   | 114      | 3990    | 183            | 5443     | 0                | 0              | 2074            | 11690            |
| 385010.1333002                          | SUMP                                                      | 501          | 1 LOT    | 31       | 1085    | 87             | 275      | 0                | 0              | 488             | 1935             |
| SUBTOTAL 385010 STRUCTURES              |                                                           |              |          | 145      | 5,075   | 270            | 5,718    | 0                | 0              | 2,562           | 13,625           |
| 385040 FIRE PROTECTION                  |                                                           |              |          |          |         |                |          |                  |                |                 |                  |
| 385040.1559001                          | SPRINKLER SYSTEM<br>(SF ALLOWANCE)                        | 501          | 125 SF   | 8        | 253     | 20             | 155      | 0                | 0              | 120             | 548              |
| SUBTOTAL 385040 FIRE PROTECTION         |                                                           |              |          | 8        | 253     | 20             | 155      | 0                | 0              | 120             | 548              |
| 385320 ELECTRICAL DISTRIBUTION          |                                                           |              |          |          |         |                |          |                  |                |                 |                  |
| 385320.1662H54                          | ALLOWANCE FOR POWER TO THE<br>BLDG                        | 600          | 1 LOT    | 40       | 1400    | 100            | 2156     | 0                | 0              | 746             | 4402             |
| 385320.1662H55                          | LIGHTING                                                  | 501          | 125 SF   | 11       | 385     | 21             | 386      | 0                | 0              | 191             | 983              |

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WESTINGHOUSE HANFORD COMPANY  
JOB NO. 04436307

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| ACCOUNT<br>NUMBER | DESCRIPTION                                                        | COST<br>CODE | QUANTITY | MANHOURS | LABOR     | EQUIP<br>USAGE | MATERIAL   | SUB-<br>CONTRACT | EQUIP-<br>MENT | ON&P<br>/ B & I | TOTAL<br>DOLLARS |
|-------------------|--------------------------------------------------------------------|--------------|----------|----------|-----------|----------------|------------|------------------|----------------|-----------------|------------------|
| 385320.1662H56    | COMMUNICATIONS                                                     | 501          | 125 SF   | 5        | 175       | 4              | 42         | 0                | 0              | 78              | 299              |
| SUBTOTAL 385320   | ELECTRICAL DISTRIBUTION                                            |              |          | 56       | 1,960     | 125            | 2,584      | 0                | 0              | 1,015           | 5,684            |
| 385630            | PROCESS SAMPLING                                                   |              |          |          |           |                |            |                  |                |                 |                  |
| 385630.1146100    | PUMPS                                                              | 700          | 2 EA     | 40       | 1400      | 19             | 1078       | 0                | 0              | 670             | 3167             |
| 385630.1147100    | SAMPLING EQUIPMENT                                                 | 720          | 1 LOT    | 40       | 1400      | 386            | 5390       | 0                | 0              | 974             | 8150             |
| SUBTOTAL 385630   | PROCESS SAMPLING                                                   |              |          | 80       | 2,800     | 405            | 6,468      | 0                | 0              | 1,644           | 11,317           |
| SUBTOTAL 385      | SAMPLING BUILDING                                                  |              |          | 289      | 10,088    | 820            | 14,925     | 0                | 0              | 5,341           | 31,174           |
| 390995            | MOBILIZATION/DENOBILIZATION                                        |              |          |          |           |                |            |                  |                |                 |                  |
| 390995.0100001    | ALLOWANCE FOR MOB/DENOB @<br>5% OF DIRECT CONSTRUCTION<br>MHRS     | 700          | 1 LOT    | 28073    | 767797    | 0              | 0          | 0                | 0              | 328617          | 1096414          |
| SUBTOTAL 390995   | MOBILIZATION/DENOBILIZATION                                        |              |          | 28,073   | 767,797   | 0              | 0          | 0                | 0              | 328,617         | 1,096,414        |
| 390999            | CONSTRUCTION ACCEPTANCE TESTING                                    |              |          |          |           |                |            |                  |                |                 |                  |
| 390999.1999991    | ALLOWANCE FOR CONST ACCEPT<br>TESTING @ 3% OF CONSTRUCTION<br>MHRS | 700          | 1 LOT    | 16844    | 460683    | 0              | 0          | 0                | 0              | 197172          | 657855           |
| SUBTOTAL 390999   | CONSTRUCTION ACCEPTANCE TES                                        |              |          | 16,844   | 460,683   | 0              | 0          | 0                | 0              | 197,172         | 657,855          |
| 390999.1999991    | CONSTRUCTION PRORATES                                              |              |          |          |           |                |            |                  |                |                 |                  |
| SUBTOTAL 390      | CONSTRUCTION PRORATES                                              |              |          | 44,917   | 1,228,480 | 0              | 0          | 0                | 0              | 525,789         | 1,754,269        |
| SUBTOTAL 3        | CONSTRUCTION                                                       |              |          | 606,385  | 2,011,743 | 105,000        | 15,113,413 | 0                | 0              | 8,875,517       | 44,217,538       |
| 411000            | CONSTRUCTION MANAGEMENT                                            |              |          |          |           |                |            |                  |                |                 |                  |
| 411000.9210001    | CONSTRUCTION MANAGEMENT                                            | XXX          | 1 LOT    | 0        | 0         | 0              | 0          | 4040000          | 0              | 0               | 4040000          |

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### 3.4 BA/BO SCHEDULE

The BA/BO schedule (Figure 3-2) reflects the requested yearly budget required to support this project. The dollars shown for the major PWBS elements are the estimated cost of expenditures by fiscal year including escalation and contingency. This schedule assumes that the funding will be authorized and available when required.

The cost shown on the BA/BO schedule are in accordance with the Project Cost Estimate and Project Schedule.

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Westinghouse Hanford Company  
WHC P.O. TVW-SVV-370252

Fluor Daniel, Inc.  
Government Services  
Contract 04436307

| Legend:<br>Budget Authority<br>Budget Outlay | PSWBS           | Dollars<br>(Millions) | FY 1995 |   |  |  | FY 1996 |          |   |   | FY 1997 |          |   |   | FY 1998 |         |
|----------------------------------------------|-----------------|-----------------------|---------|---|--|--|---------|----------|---|---|---------|----------|---|---|---------|---------|
|                                              |                 |                       | 3       | 4 |  |  | 1       | 2        | 3 | 4 | 1       | 2        | 3 | 4 | 1       | 2       |
| Title II Design                              | 1.4.1.07.01.3.4 | \$10,530 ✓            |         |   |  |  |         | \$10,530 |   |   |         |          |   |   |         |         |
|                                              |                 |                       |         |   |  |  |         | \$10,530 |   |   |         |          |   |   |         |         |
| Title III Design & Inspection                | 1.4.1.07.01.4.5 | \$5,380 ✓             |         |   |  |  |         | \$2,095  |   |   |         | \$2,662  |   |   |         | \$623   |
|                                              |                 |                       |         |   |  |  |         | \$2,095  |   |   |         | \$2,662  |   |   |         | \$623   |
| Procurement                                  | 1.4.1.07.01.4.2 | \$14,923              |         |   |  |  |         | \$6,739  |   |   |         | \$8,184  |   |   |         |         |
|                                              |                 |                       |         |   |  |  |         | \$6,739  |   |   |         | \$8,184  |   |   |         |         |
| Construction Management                      | 1.4.1.07.01.4.1 | \$4,873               |         |   |  |  |         | \$1,920  |   |   |         | \$2,908  |   |   |         | \$45    |
|                                              |                 |                       |         |   |  |  |         | \$1,920  |   |   |         | \$2,908  |   |   |         | \$45    |
| Construction                                 | 1.4.1.07.01.4.7 | \$54,824              |         |   |  |  |         | \$21,594 |   |   |         | \$32,721 |   |   |         | \$509   |
|                                              |                 |                       |         |   |  |  |         | \$21,594 |   |   |         | \$32,721 |   |   |         | \$509   |
| Project Management                           | 1.4.1.07.01.2   | \$3,370               |         |   |  |  |         | \$1,611  |   |   |         | \$1,226  |   |   |         | \$533   |
|                                              |                 |                       |         |   |  |  |         | \$1,611  |   |   |         | \$1,226  |   |   |         | \$533   |
| Regulatory Compliance                        | 1.4.1.07.01.7   | \$1,190               |         |   |  |  |         | \$500    |   |   |         | \$500    |   |   |         | \$190   |
|                                              |                 |                       |         |   |  |  |         | \$500    |   |   |         | \$500    |   |   |         | \$190   |
| Total BA/BO                                  |                 | \$95,090              |         |   |  |  |         | \$44,989 |   |   |         | \$48,201 |   |   |         | \$1,900 |
|                                              |                 |                       |         |   |  |  |         | \$44,989 |   |   |         | \$48,201 |   |   |         | \$1,900 |

Figure 3 - 2  
SNF Canister Storage Building  
Conceptual Design Report  
BA/BO Schedule



### 3.5 DESIGN TO COST

#### 3.5.1 Introduction

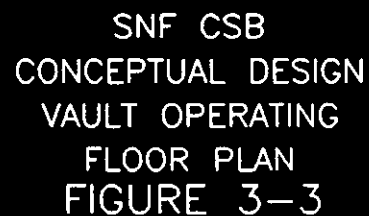
One of the key result areas identified in the SNF CSB team alignment meeting as essential to achieving the project mission was the requirement to design and build the SSF for \$80 million or less. The concurrent development of the Performance Specification and the Conceptual Design Report resulted in a cost estimate which identified the design approach taken for ALARA compliance as a major cost driver. An iteration on the Conceptual Design identified alternate options for radiation control measures which eliminate certain facility features and provide for cost reduction which satisfy the \$80 million target. Further evaluation of these options and validation of the cost figures is proposed for Advanced Conceptual Design. The cost estimate will be formally revised as a deliverable of this phase.

#### 3.5.2 Modifications and Cost Reductions

The following design modifications were identified as cost reduction options in response to "design to cost" considerations. Cost savings are rough order of magnitude estimates. Refer to Figure 3-3 for a revised facility floor plan which reflects these proposed modifications.

##### 3.5.2.1 Transfer Cask Shielding

- a. If the transfer cask shielding was increased to limit radiation exposure levels to 0.2 mrem/hr, the Wash Down Area and Load-In/Load-Out Area would no longer need to be constructed of concrete for shielding. Instead, the Load-In/Load-Out Area could be constructed as a steel structure. The Wash Down Area could consist of a weather roof only with a spray booth. Estimated cost savings are \$3,480,000.
- b. Furthermore, virtually all shield doors, shield windows and remote equipment could be eliminated. All work could be conducted as contact-maintained operations. Estimated cost savings are \$2,222,000.
- c. Likewise, the MCO/Cask Transfer Tunnel could be eliminated. Cost savings are estimated to be \$2,600,000.
- d. In addition, the 5-ton crane in the Wash Down Area could be eliminated. Impact limiters could be lifted by the Load-In/Load-Out crane. The estimated cost savings amount to \$650,000.



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### 3.5.2.2 Single Railroad Line

- a. Elimination of the second railroad line and switch could provide a \$190,000 cost reduction.
- b. Also, the shield berm between railroad lines would be eliminated, providing for a \$96,000 cost savings.
- c. Furthermore, approximately one half of the Load-In/Load-Out metal structure could be deleted. The cost impact amounts to a \$290,000 savings.

### 3.5.2.3 Mobile HVAC, Monitoring and Electrical Systems

- a. If the Safety Class 2 HVAC systems in the MCO/Cask Transfer Tunnel and Operating Area were replaced by mobile, redundant, Safety Class 2 HVAC systems in the crane which would service the contact-maintained cask, a cost savings of \$966,000 could be realized.
- b. Similarly, Safety Class 2 continuous airborne effluent monitors (CAEMs) could be replaced with redundant, non-safety class stack monitors. The six Safety Class 2 particulate/gas monitors used to activate the Safety Class 2 HVAC system for the Operating Area could also be replaced with two mobile, Safety Class 2 particulate/gas monitors on the crane to serve the contact-maintained cask. Cost savings are estimated to be \$966,000.
- c. Also, the two Safety Class 2 generators, rooms and electrical trains could be replaced by two mobile, Safety Class 2 electrical systems for the crane to serve the contact-maintained cask. Estimated cost savings are \$580,000.

### 3.5.2.4 Plant Design Life

- a. Reduction in the requirement for a 200-year service life for the facility structure to 75 years would eliminate the need for additional shotcrete and concrete protection. Cost savings would amount to \$1,547,000.
- b. Also, additional chemical testing of soils; additional physical and chemical testing of concrete aggregates; and concrete mix design aging effects studies could be avoided, saving \$196,000.

### 3.5.2.5 Facility Reductions

- a. Elimination, reduction or relocation of the following areas of the permanent facility could amount to approximately a \$1,000,000 savings.

- The transfer tunnel to the adjacent Stabilization Facility and associated Operating Area floor space could be eliminated.
- The MCO Storage Area could be eliminated.
- The Non-Radioactive Maintenance Area could also be eliminated.
- Also, the Non-Regulated (Blue) Change Room could be relocated to adjacent outside trailers.
- Final, detailed shielding and structural analysis calculations could confirm the ability to reduce the Operating Area floor deck thickness.

### 3.5.3 Revised Total Cost Estimate

Table 3-9 summarizes the estimated rough order of magnitude cost savings of \$14.8 million to the total cost estimate. These "design to cost" options as proposed above could reduce the total cost of the SNF CSB facility to approximately \$80.3 million.

Table 3-9

SNF CSB Conceptual Design  
Design to Cost  
Modifications and Reductions  
(\$ 1995)

|                                                                                                                                                                                               | (\$ x 1,000) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Conceptual Design Report<br>Total Estimated Cost (TEC)                                                                                                                                        | 95,089       |
| Design to Cost Reductions                                                                                                                                                                     |              |
| 1. Steel construction of Wash Down Area and<br>Load-In/Load-Out Area structures                                                                                                               | <3,480>      |
| 2. Elimination of shield doors, shield windows<br>and remote equipment                                                                                                                        | <2,222>      |
| 3. Elimination of MCO/Cask Transfer Tunnel                                                                                                                                                    | <2,600>      |
| 4. Elimination of Wash Down Area Crane                                                                                                                                                        | <650>        |
| 5. Elimination of second railroad line and<br>switch                                                                                                                                          | <190>        |
| 6. Elimination of railroad line shield berm                                                                                                                                                   | <96>         |
| 7. Reduced Load-In/Load-Out Area structure                                                                                                                                                    | <290>        |
| 8. Mobile HVAC system                                                                                                                                                                         | <966>        |
| 9. Mobile particulate/gas monitoring system                                                                                                                                                   | <966>        |
| 10. Mobile electrical power system                                                                                                                                                            | <580>        |
| 11. Deletion of 200-year facility structure<br>service life                                                                                                                                   | <1,547>      |
| 12. Deletion of additional soils and concrete<br>testing for extended structural facility<br>service life                                                                                     | <196>        |
| 13. Elimination of Stabilization Facility<br>Transfer Area, MCO Storage Area, Non-<br>Radioactive Maintenance Area, Non-Regulated<br>Change Room and reduced Operating Area deck<br>thickness | <1,000>      |
| Design to Cost TEC                                                                                                                                                                            | <hr/> 80,306 |

## 4.0 LEVEL 1 SCHEDULE

### 4.1 SCHEDULE BASIS

This schedule is based on modifying the Hanford Waste Vitrification Plant (HWVP) Canister Storage Building (CSB) design in accordance with Concept 2D developed during the SNF CSB Trade Studies in May 1995. It is also based on using the partially completed construction of the floor mat and walls from the HWVP Project. In order to achieve an early start of construction for the vault area, the key decision process to start construction has been split into two phases. This approach allows the design of the at-grade portion of the building to be completed while the vault walls are poured and backfilled.

All key decisions and milestone dates were received from Westinghouse Hanford Company and serve as the basis for the development of this Level One (1) schedule, Figure 4-1, for the Conceptual Design Report. The funding basis for this schedule is found in the BA/BO schedule, Figure 3-2.

### 4.2 Schedule Assumptions

A list of assumptions required to achieve successful completion of the project milestone dates follows. The list may be modified during Advanced Conceptual Design once a detailed logic network schedule is developed. It is assumed that there will be no annual funding constraints for the duration of the project.

#### 4.2.1 Engineering and Design Assumptions

All changes to the design basis should be identified and included in the Advanced Conceptual Design Report prior to the start of Detailed Design. The basis should not change after this point. Client review changes may impact the end of Detailed Design.

#### 4.2.2 Procurement and Construction Assumptions

There is no shortage of local craft labor or specialty contractors in the area.

Construction is based on a standard forty hour work week. Scheduled overtime is excluded from this schedule.

The concrete slab and walls that are currently in place will be used with some changes required to complete the concrete vault walls and operating floor.

The walls for all vaults will be formed and poured simultaneously.

SNF CSB Conceptual Design Report  
Westinghouse Hanford Company  
WHC P.O. TW-5WV-370252

Fluor Daniel, Inc.  
Government Services  
Contract 04436307

| Description                   | Early Start | Early Finish | FY 1995 |   |  |  | FY 1996 |   |   |   | FY 1997 |   |   |   | FY 1998 |   |   |   |
|-------------------------------|-------------|--------------|---------|---|--|--|---------|---|---|---|---------|---|---|---|---------|---|---|---|
|                               |             |              | 3       | 4 |  |  | 1       | 2 | 3 | 4 | 1       | 2 | 3 | 4 | 1       | 2 | 3 | 4 |
| <b>Key Decisions</b>          |             |              |         | ☆ |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| KD # 1,2,3a (Substructure)    | 18-Aug-95   |              |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| KD # 3b (Remainder)           | 04-Oct-95   |              |         | ☆ |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| <b>Key Milestones</b>         |             |              |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Start Definitive Design       | 02-Oct-95   | 02-May-96    |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Complete Definitive Design    |             | 30-Sep-97    |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Accept Construction           |             | 30-Oct-97    |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Closeout Construction         |             | 08-Nov-96    |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Issue SAR to DOE-RL           |             | 25-Apr-97    |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Approval of SAR               |             |              |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Authorization to Ship Fuel    | 01-Dec-97   |              |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| <b>Activities</b>             |             |              |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Title II Design               | 02-Oct-95   | 02-May-96    |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Title III Design & Inspection | 30-Oct-95   | 30-Oct-97    |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Procurement                   | 02-Oct-95   | 31-Mar-97    |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Construction Management       | 27-Dec-95   | 30-Oct-97    |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Construction                  | 27-Dec-95   | 30-Oct-97    |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Project Management            | 02-Oct-95   | 30-Nov-97    |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |
| Safety Analysis               | 02-Oct-95   | 21-Nov-97    |         |   |  |  |         |   |   |   |         |   |   |   |         |   |   |   |

Figure 4-1  
SNF Canister Storage Building  
Conceptual Design Report  
Level One Project Master Schedule

Rebar for the walls and for the operating floors will be pre-assembled and set in place with cranes.

Structural steel buildings will be prefabricated in shops, and assembled in the field. There is no shortage of material locally, including concrete batch plant requirements.

Long lead equipment items will be identified very early so as to not delay construction.

There are no shortages of construction equipment in the area.

Construction of the operating decks will be concurrent in all three vaults.

Storage tube installation will be concurrent in two vaults.

#### **4.2.3 Safety Regulatory Compliance and Permitting Assumptions**

All permits and regulatory compliance approvals will be in place to allow start of construction and start-up.

#### **4.3 SCHEDULE CONCLUSION**

An aggressive schedule has been established to meet project requirements. Methods of obtaining expeditious funding and permit approvals must be developed in order to meet this schedule. The Architect/Engineer will develop a detailed logic network schedule during the Advanced Conceptual Design phase of the project and include as many phased-construction and creative constructability techniques as required to meet the milestone dates.



## 5.0 SYSTEMS ENGINEERING

The Systems Engineering for the SNF CSB was performed by Fluor Daniel using CORE, a requirements management software tool developed by Vitech Engineering. CORE operates on a PC, in the MicroSoft WINDOWS environment. CORE is fully compatible with RDD-100, which is currently used by WHC to model systems.

The Conceptual Design effort spanned the two months between May and July, 1995. It was focused primarily on identifying differences from the HWVP CSB design, and on obtaining a valid cost estimate. WHC provided a draft Performance Specification for use in support of this effort, which was subsequently parsed and incorporated as Originating Requirements in the CORE database. The Performance Specification, together with relevant portions of the extant HWVP design, provided the basis for performing a top level functional analysis and allocating functions to CSB structures, systems, and components.

### 5.1 FUNCTIONAL ANALYSIS

The mission of the SNF CSB is to provide safe staging and storage of K Basin SNF until a decision on its final disposition is reached and implemented. This mission is decomposed into six primary functions:

1. Protect the health & safety of the public and the employees
2. Perform the staging function of K-Basin SNF prior to stabilization
3. Perform the storage function of stabilized SNF
4. Maintain MCO environment and integrity
5. Perform support functions for operations and maintenance
6. Collect, process, and manage waste disposal

#### 5.1.1 Protect Health and Safety

A primary function of the CSB systems is to provide protection of the public and onsite worker health and safety. The facility is designed to minimize personnel exposures to external and internal radiological hazards, provide adequate radiation monitoring and alarm systems, and provide adequate space for health physics activities. Primary radiation protection is provided by use of engineered controls, e.g., confinement, ventilation, remote handling, equipment layout, and shielding. This function is decomposed into the following subsidiary functions:

- F.1.1 Contamination Control
- F.1.2 Protect the Environment
- F.1.3 Mitigate or Prevent DBAs
  - F.1.3.1 Mitigate a Design Basis Fire
  - F.1.3.2 Mitigate a Design Basis Power Failure

- F.1.3.3 Withstand a Design Basis Earthquake
- F.1.3.4 Withstand a Design Basis Wind
- F.1.3.5 Mitigate a Design Basis Flood
- F.1.3.6 Withstand a Design Basis Volcano Eruption
- F.1.3.7 Mitigate MCO Overpressurization DBA
- F.1.3.8 Mitigate MCO Drop DBA
- F.1.3.9 Mitigate MCO Overheating DBA
- F.1.3.10 Mitigate Hydrogen Burn/Explosion DBA

Each of these subsidiary functions will be analyzed and detailed response procedures developed during Detailed Design. For the Conceptual Design, the functional decomposition was taken to this level, and these functions allocated to structures, systems, and components for inclusion in the cost estimate. To illustrate, the first DBA, F.1.3.1 "Mitigate a Design Basis Fire" is presented in Figure 5-1. Other functional hierarchy diagrams are available.

Although a detailed Fire Hazards Analysis has yet to be performed, it is possible to conceive of the kinds of fires which the Fire Protection System will need to mitigate. These include trash fires, electrical fires, and possible solvents or grease fires involving limited quantities of combustible material.

One type of fire which may or may not be credible is a pyrophoric event involving the uncontrolled oxidation of uranium metal. Such events are typically associated with combustible geometries having very high surface to volume ratio, and poor heat transfer. It is not believed at present that a credible scenario involving a uranium metal fire exists in the context of planned CSB operations. However, if credible, this issue could have a substantial effect in the design of the Fire Protection System. Results are pending completion of a Fire Hazards Analysis in ACD. The hierarchy diagram in Figure 5-1 shows the physical architecture of the Fire Protection System, and also can display the relations of the system to other elements in the Systems Engineering database.

#### 5.1.2 Perform the Staging Function

In the staging mode of operations the SNF CSB receives multi-canister overpacks (MCOs), each containing ten canisters stacked five high, filled with K Basin SNF. The SNF CSB provides short-term storage of the MCOs until the stabilization facilities are available, and stages the MCOs for transfer to stabilization. An overview of the staging function is depicted as a functional flow block diagram in Figure 5-2.

The first function, F.2.1.2 "Receive MCO(K)", is further decomposed into its constituent subsidiary functions listed below, and the resulting steps are also plotted in a functional flow block diagram shown in Figure 5-3. These functions have been allocated to systems and components for the purpose of generating an equipment

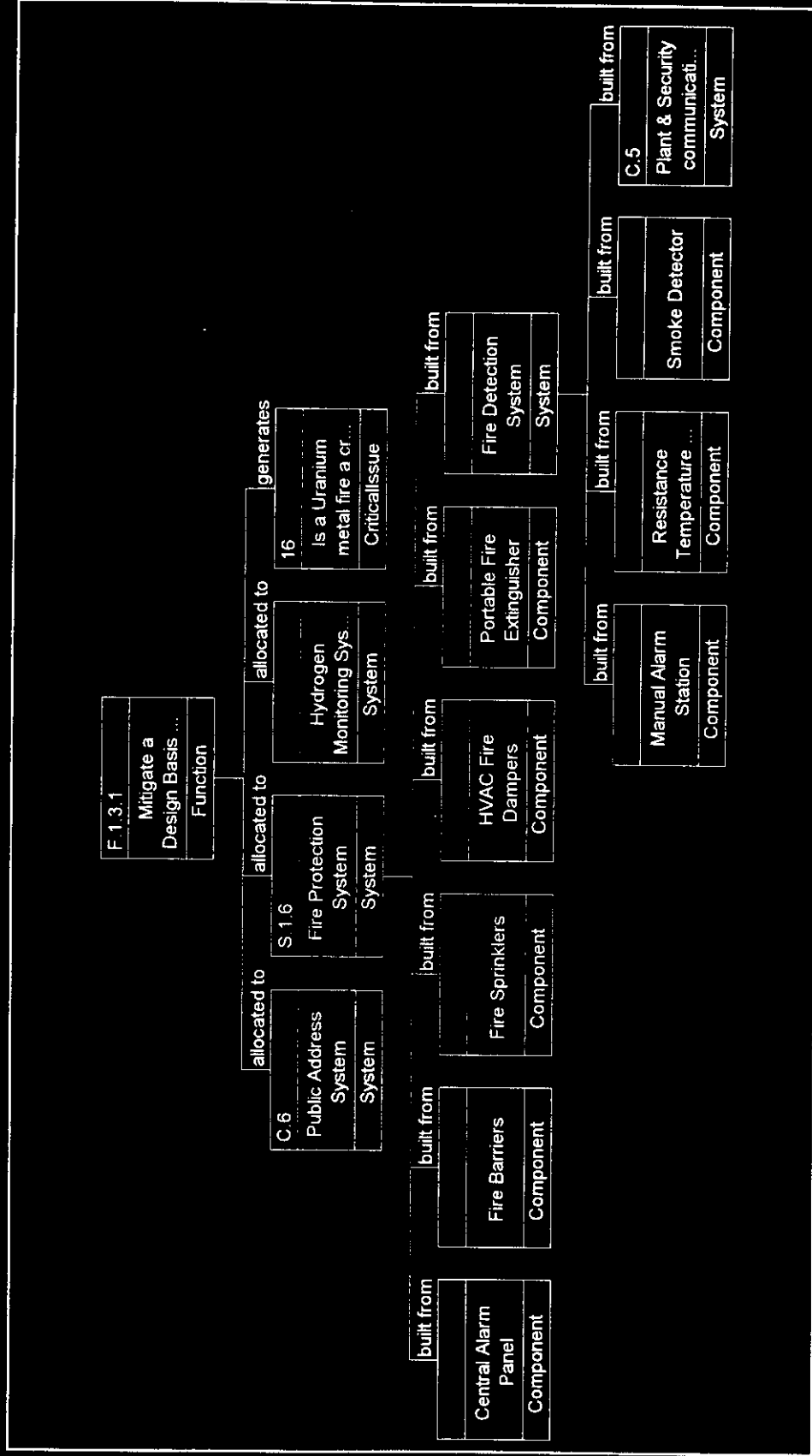


Figure 5-1  
 Fire Protection Function Hierarchy Diagram

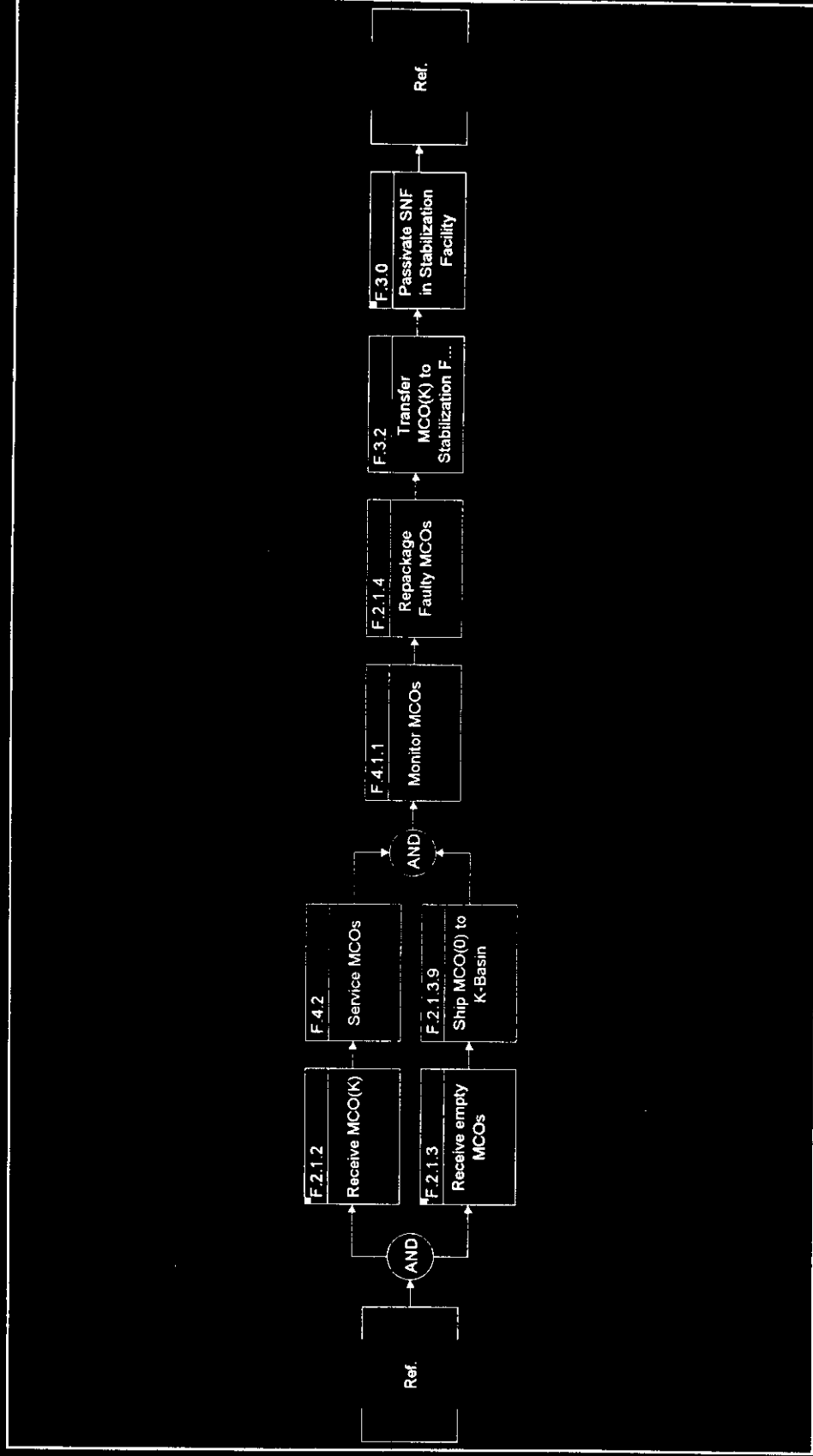


Figure 5-2  
 CSB Functional Flow Block Diagram - Top Level

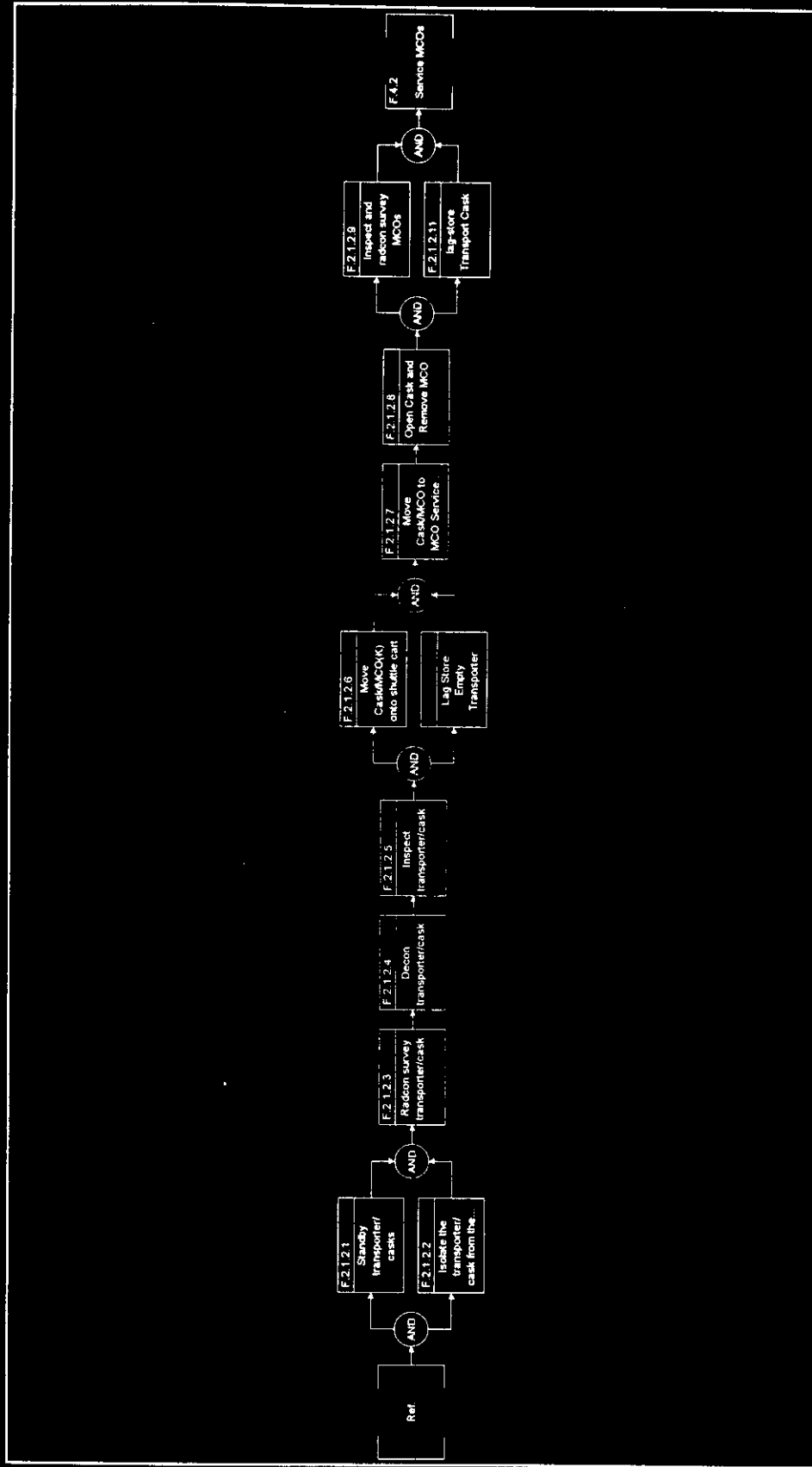


Figure 5-3  
 MCO (K) Receiving and Handling Process

list to support the Conceptual Design cost estimate.

- F.2.1.2.5 Wash down & inspect transporter/cask
- F.2.1.2.6 Move Cask/MCO(K) onto shuttle cart
- F.2.1.2.7 Open Cask and Remove MCO
- F.2.1.2.8 Move MCO to receiving area position
- F.2.1.2.9 Service MCOs
- F.2.1.2.10 Transfer MCO(K) to Operating Deck Area
- F.2.1.2.11 Lag-store transporter/cask

A parallel activity is F.2.1.3, Receive and store new MCOs. A functional flow block diagram is shown in Figure 5.4. The new, empty MCO is designated MCO(0), and one is loaded into the shipping cask for transfer back to K-Basin with each return trip. This step includes reattachment of the inflatable seal between the MCO(0) and the cask. This function has been decomposed as follows:

- F.2.1.3 Receive and store new MCOs
  - F.2.1.3.1 Receive the conveyance
  - F.2.1.3.2 Standby one conveyance
  - F.2.1.3.3 Receipt inspect new MCO(0)s
  - F.2.1.3.4 Move the conveyance within the site
  - F.2.1.3.5 Unload MCO(0) off the conveyance
  - F.2.1.3.6 Dispatch the conveyance
  - F.2.1.3.7 Place the MCO(0) in lag-storage
  - F.2.1.3.8 Move the MCO(0) from lag-storage to transporter/cask
  - F.2.1.3.9 Ship MCO(0) to K-Basin

### 5.1.3 Perform Storage Mode

While the SNF is being processed in the stabilization facilities, the SNF CSB will be incrementally re-configured for interim storage. In the storage mode of operations the SNF CSB receives MCOs containing processed SNF, provides interim storage of the MCOs until their final disposition has been determined and the long-term repository is available, and stages the MCOs for transfer to final disposition. This function is labeled MCO(S) Storage.

- F.3.0 Passivate SNF in Stabilization Facility
  - F.3.1 Stage MCO(K)s for transfer
  - F.3.2 Transfer MCO(K) to Stabilization Facility
  - F.3.3 Receive MCO(S) from Stabilization Facility
- F.7.0 Storage Function
  - F.7.1 Receive MCO(S)s from Stabilization Facility
  - F.7.2 Reconfigure MCO for Storage
  - F.7.3 Place MCO(S) in Storage Tube
  - F.7.4 Stages MCO(S)s for transfer to final disposition
  - F.7.5 Dispositions Stabilized SNF

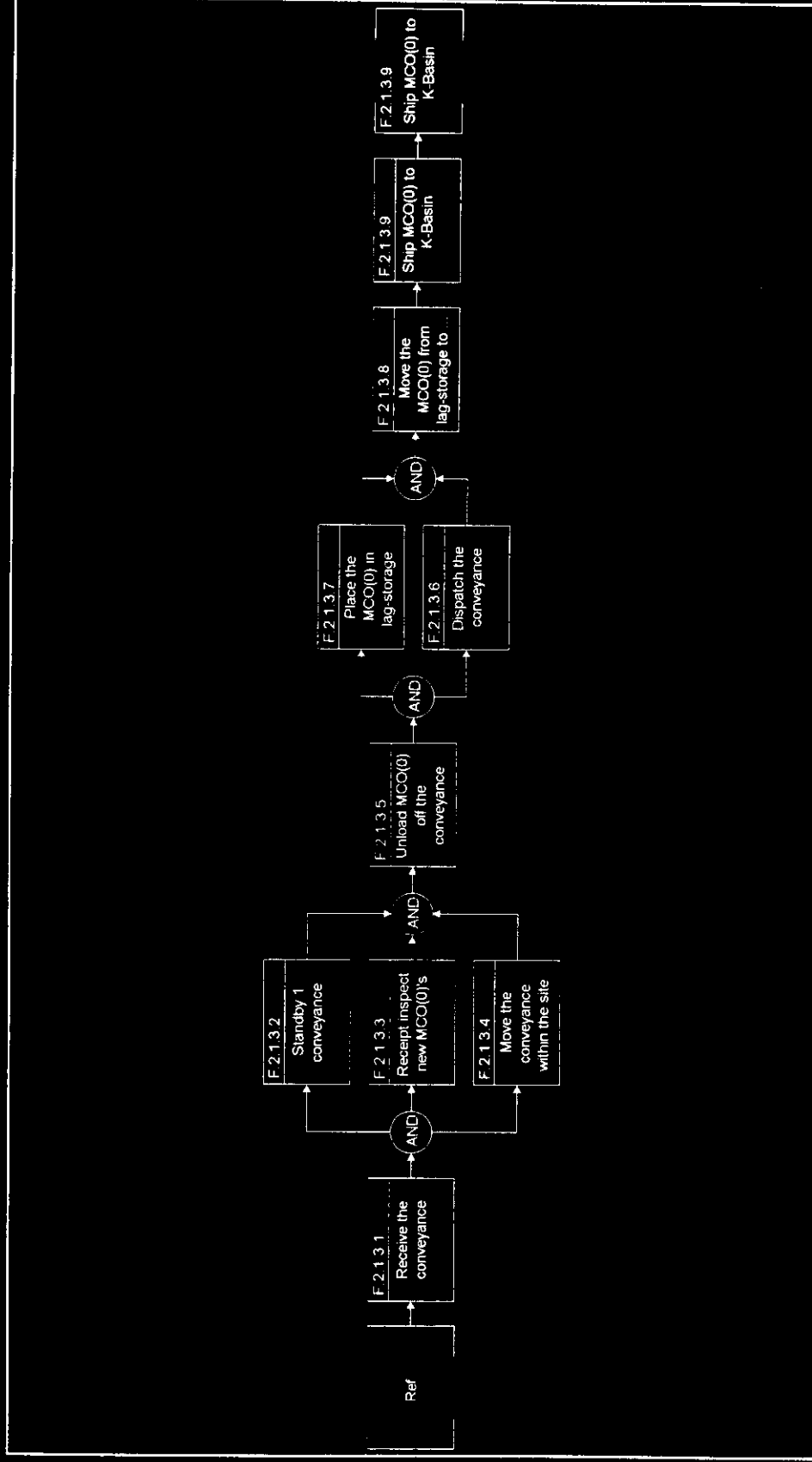


Figure 5-4  
 New MCO Receipt & Handling

Note: The details of the Stabilization Facility interface have not yet been established. The Conceptual Design does not include features to accommodate these functions in the same level of detail as for the staging functions.

#### **5.1.4 Maintain MCO Environment & Integrity**

During both the staging and storage modes of operation, the CSB has all the necessary provisions to control the MCO environment. Capability to control the MCO environment includes the following function:

Control and maintain the temperature of the MCO cooling media.

##### Monitor MCO environment.

The SNF CSB includes all the necessary provisions to monitor the MCO environment during the staging and storage modes of operation. The capability to monitor the MCO environment implements the following functions:

- a. Monitor the temperature of the MCO cooling media;
- b. Monitor contamination of the MCO environment and detect MCO leaks; and
- c. Monitor personnel radiation exposure.

##### Maintain MCO integrity

The SNF CSB shall include all the necessary provisions to maintain the integrity of the MCO during the staging and storage modes of operation. The capability to maintain the integrity of the MCO shall implement the following functions:

- a. Service the MCO, including sampling, venting, and purging, .
- b. Perform radiological survey(s) of the MCO.
- c. Decontaminate the MCO.
- d. Perform physical inspections of the MCO.
- e. Repackage MCOs (placing the MCO inside an MCO overpack) that exhibit leakage.

#### **5.1.5 Provide Support Functions**

The SNF CSB shall include all the necessary accommodations to facilitate SNF CSB operations and maintenance activities during the staging and storage modes of operation.

- a. Receive and store chemicals, materials, and supplies necessary for its operation and maintenance.
- b. Perform maintenance of both radioactive and non-radioactive equipment to support plant operations and to minimize



- downtime. The radioactive equipment maintenance area shall include appropriate minimal decontamination facilities and shall accommodate remote and contact maintenance.
- c. Provide operational support for rail car and truck loading and unloading areas, cranes, and MCO handling equipment.
  - d. Provide operational utility services such as electrical power, communications, compressed gases, sanitary water, raw water, and sewers.
  - e. Provide contaminated change rooms including lockers, emergency showers, and health physics areas.
  - f. Provide offices and work areas for personnel in non-contaminated areas.
  - g. Monitor and control hydrogen generation and MCO radiological offgas. The hydrogen generation and MCO offgas rates shall be considered as part of the design process to determine the possibility that explosive concentrations may exist, and implement the appropriate measures for its safe handling.
  - h. Maintain HVAC airflow from non-contaminated to progressively more contaminated areas. Consideration shall be given to providing separate HVAC supply systems for contaminated and non-contaminated areas.

#### 5.1.6 Manage the Disposal of Incidental Waste

The generation of solid, liquid, and effluent incidental waste as result of the SNF CSB operations shall be minimized. The capability to manage the disposal of incidental waste shall implement the following functions:

- a. Collect and contain the solid, liquid, and airborne/gaseous effluent waste generated throughout its operations to minimize contamination and exposure to as minimum as reasonably achievable. SNF CSB operations include the startup, staging, and interim storage modes of operation.
- b. Characterize the solid, liquid, and airborne/gaseous effluent waste generated throughout its operations to determine the radioactive and hazardous constituent quantities, and to enable its sorting, classification, treatment, and accountability.
- c. Treat and package the solid, liquid, and airborne/gaseous effluent waste generated throughout its operations for shipment and disposal by others.

- d. Store the solid, liquid, and airborne/gaseous effluent waste generated throughout its operations in accordance with environmental regulations.
- e. Transfer the solid, liquid, and airborne/gaseous effluent waste generated throughout its operations to final disposition.

The waste management functions have been decomposed into the following specific subsidiary functions.

#### F.5 Waste Processing

- F.5.1 Collects Solid waste
- F.5.2 Collects Liquid Waste
- F.5.3 Collects Gaseous Effluent Waste
- F.5.4 Characterizes Waste.
- F.5.5 Classifies Waste.
- F.5.6 Treats Waste
- F.5.7 Stores Waste
- F.5.8 Dispositions Waste

### 5.2 INTERFACE CONTROL PLAN

The Interface Control Plan is a subsidiary document to the Systems Engineering Management Plan (SEMP), which is not scheduled for publication until the outset of detailed design. Nevertheless, both the internal and external interfaces have been conceptualized, and where possible the links servicing those interfaces are specified to the extent necessary to support the cost estimate.

#### 5.2.1 External Interfaces

Interface information for the piping and civil engineering interfaces at the facility is well-developed and based on existing CSB design. However, interface effects reveal that additional design information is needed for the locomotive, truck, and cask used for MCO transport. Basic information includes dimensions such as elevation of the trailer/railcar, the temperature of the MCO and cask when they arrive, location of cask trunions, approximate engine size (for ventilation design if combustion engines will be allowed to enter the building), and combustible load (for fire protection).

Interfaces with the Hanford Site transportation services. The locomotives that drive the SNF transporters are provided by the Hanford Site Transportation services group. These locomotives and trucks include the necessary provisions to facilitate their accessing, arrival, handling, and dispatching at the SNF CSB.

Interfaces with the SNF packaging and transportation systems. MCO/casks are transported and delivered to the SNF CSB on rail car

and/or truck transporters. The transportation casks and transporters will be provided by the SNF Transportation System project. The locomotives will be obtained from the Hanford Site Transportation Services.

Interface with SNF truck transporter. The transporters include the necessary provisions to facilitate their arrival, handling, unloading, loading, and dispatch at the SNF CSB. Handling includes operations to move, isolate, survey, wash down, inspect, and lag-store the transporters.

Interface with SNF transportation cask. The transportation casks include the necessary provisions to facilitate their handling, and loading and unloading at the CSB. Handling includes operations to survey, wash down, inspect, and lag-store the transportation cask, load in new MCOs, ship/return to K-Basin.

Interface with existing rail lines. Rail access to the SNF CSB will be provided by a new rail spur that connects to the Hanford site rail system. This is shown on the Site Plan, Figure 2-1.

Interface with existing roadways. Road access to the SNF CSB will be provided by a new roadway that connects to the Hanford Site roads. This is shown on the Site Plan, Figure 2-1.

Interface with SNF MCO. The MCOs include the necessary provisions to facilitate their receipt, handling, storage, and staging at the SNF CSB. Handling includes operations to shield, off-load, move, position, lag-store, retrieve, and configure the MCOs. The MCOs also include the necessary provisions to enable SNF CSB control and monitoring of the MCO environment, and maintenance of MCO integrity. These include operations to retrieve, move, survey, inspect, overpack, service the MCOs, receive, handle & ship new empty MCOs to K-Basin (see Figure 5-4).

Although the MCO relief device is not part of the facility design, it is of prime importance that the CSB is designed to detect and prevent accident scenarios involving abnormal MCO conditions. The first step is to determine the problems that could credibly occur during staging and storage.

Assumptions have been made during the Conceptual Design with regard to the details of mating the MCO to a lifting fixture on the MCO Handling Machine (MHM). The fixture consists of an air-operated grapple which will insert into recesses machined in top surface of the MCO closure head. These assumptions cannot be verified until WHC publishes details of the MCO design.

When the MCO is empty, the closure head is not attached, so the new MCOs will have to be handled in a different manner. It is conceived that the MCO will be lifted using an inflatable mandrel

operated from the auxiliary hook on the bridge crane in the cask loading/unloading area. The mandrel will press against the inside surface of the MCO, to permit lifting and lowering the MCO into a waiting shipping cask for transport to the K-Basin.

Interface with the SNF stabilization facilities. The SNF stabilization facility is proposed as an adjacent structure sharing the south wall of the CSB. During the stabilization, the CSB transfers the staged MCO(K) to the SNF stabilization facilities via a transfer canal similar to the one at the north end of the vault.

This interface is assumed to consist of another tunnel and conveyor cart apparatus, similar to the one provided for the receiving function. The Stabilization Facility will be located immediately to the South of the CSB. The tunnel is depicted on Figure 2-2 and 2-6. The Stabilization Facility conveyor cart will have to be designed to accept MCO overpacks, as well as MCOs. This interface will perform two-way traffic functions during the stabilization campaign.

Interfaces with Hanford Site infrastructure and utilities. The SNF CSB connects to elements of the Hanford Site infrastructure, and receives services needed for its operation from the Hanford Site utilities.

Interface with existing security system. Security of the SNF CSB site and facilities will be provided by connecting the SNF CSB security systems to the Hanford Site security system.

Interface with the existing communications network. Local area network and telephone communications will be provided to the SNF CSB by connecting the SNF CSB communications system to the Hanford Site communication network.

Interface with the existing electric power grid. Electric power service will be provided by connecting to the Hanford Site electric power grid in accordance with requirements of the 200 East Area Electrical Utilities.

Interfaces with the existing water and sewage systems. Water service will be provided by connecting the SNF CSB water system to the HWVP Site water system. Sewage service, if required, will be provided to the SNF CSB by connecting the SNF CSB sewage system to a manhole installed for the HWVP sewer system, or by constructing an independent collection and treatment system to serve only the SNF CSB site.

Interfaces with other Hanford Site programs. Other Hanford Site programs provide support to the SNF CSB by receiving the solid, liquid, and airborne/gaseous effluent waste generated throughout operations and maintenance.

### 5.2.2 Logical Interfaces & Physical Links

As previously mentioned, the Conceptual Design has been laid out using CORE. This tool automatically tracks both physical (hardware) and logical interfaces, identifying the physical link for each interface, and tracks the link operating characteristics, and design bases. As can be seen from Table 5-1, some of the physical links are not yet well defined, and remain to be developed during ACD and Detailed Design.

Each interface is treated as an element in CORE, and possesses its own set of attributes including description, discipline ownership, and identification symbols. In addition, each has a set of relationships to other elements in the design, including elements documenting technical risks faced by the project. For example, the first interface is the CSB to Stabilization Facility interface:

|                              |                                                                                         |
|------------------------------|-----------------------------------------------------------------------------------------|
| Interfacing Components:      | System: MCO/Cask Service Area<br>System: Passivation Facility                           |
| Comprised of Physical Links: | Shuttle cart/conveyor                                                                   |
| Serviced By Function:        | Receive MCO(S)s from Stabilization Facility                                             |
| Traced From Requirements:    | Originating Requirement: Allow Co-location of Stabilization Facility                    |
| Risks:                       | Link requirements for shuttle cart between CSB and Stabilization Facility are undefined |

### 5.3 HUMAN FACTORS ENGINEERING CONSIDERATIONS

The SNF CSB shall be designed to be comfortable and natural for humans to operate and maintain. Design considerations shall be given to the guidelines in MIL-STD-1472D, *Human Engineering Design Criteria for Military Systems, Equipment, and Facilities* (DOD 1989).

The following components have been identified for application of Human Factors Engineering of the Man Machine interface during detailed design: Distributed Control System (System) Operator's Console (Subsystem) and Shutdown Control Panel (Component) In addition, the following concepts are utilized wherever practicable:

- a. Instrument readouts are located at average eye level for ease of reading and control, without requiring drastic shifts of body position.
- b. Alarms and annunciators shall be located near the operational personnel and convey the proper action required.

Table 5-1 - Canister Storage Building System Interfaces

| Interfaces                                                                                    | Interfacing Components                                                                                  |
|-----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| CSB to SF interface<br>- physical link: Shuttle cart/conveyor                                 | MCO/Cask Service Area (System)<br>Passivation Facility (System)                                         |
| DCS - Fire Protection System Interface<br>- physical link: undefined                          | Distributed Control System (System)                                                                     |
| DCS - HP interface<br>- physical link: Highway Interface Unit                                 | Distributed Control System (System)                                                                     |
| DCS - HVAC Controls<br>- physical link: Remote Terminal Unit                                  | Distributed Control System (System)<br>HVAC Control & Monitoring (System)                               |
| DCS - LAN interface<br>- physical link: Highway Interface Unit                                | Distributed Control System (System)                                                                     |
| DCS - Utility Controls<br>- physical link: Remote Terminal Unit                               | Distributed Control System (System)<br>Utility Systems I&C (System)                                     |
| DCS - Vault Temperature Sensors<br>- physical link: Remote Terminal Unit                      | Distributed Control System (System)<br>Vault Temperature Monitoring System (System)                     |
| Decon Area to Waste Disposal<br>- physical link: Holding Tank                                 | Waste Handling Area (System)                                                                            |
| HVAC to HPS Interface<br>- physical link: Undefined                                           | Health Protection System (System)<br>HVAC Control & Monitoring (System)                                 |
| Interface with existing Communications network<br>- physical link: Private Telephone Exchange | General Plant Telephone System (System)                                                                 |
| Interface with existing electrical grid<br>- physical link: Pole-mounted fuse link            | Electrical Power Distribution System (System)                                                           |
| Interface with existing rail lines<br>- physical link: CSB Rail Spur                          | Cask Load-in/load-out Area Structure (System)                                                           |
| Interface with Hanford Site LLW facility<br>- physical link: Undefined                        | Waste Processing System (System)                                                                        |
| Load-in Area to MCO Service<br>- physical link: Shuttle cart/conveyor                         | Cask Load-in/load-out Area Structure (System)<br>MCO/Cask Service Area (System)                         |
| LWS to Hanford TEF interface<br>- Clean Drain (DRX) pipeline                                  | Liquid Waste Collection System (System)<br>Hanford Treated Effluent Disposal Facility (External System) |
| Compressed Air to HPS<br>- physical link: Air pressure regulator                              | Health Protection System (System)<br>Instrument Air System (System)                                     |
| Compressed Air to LWS<br>- physical link: Air pressure regulator                              | Instrument Air System (System)<br>Liquid Waste Collection System (System)                               |
| Process Water to Air Compressor                                                               | Air Compressor                                                                                          |

- c. Equipment shall be accessible for ease of operation and maintenance.
- d. Valve handles shall be sized properly and located for ease of operation.
- e. Labels, legends, placards, signs, or markings shall be provided whenever it is necessary to identify, interpret, follow procedures, or avoid hazards, except where it is obvious to the observer.
- f. Facilities shall be designed for both men and women operators.
- g. Lighting levels shall be verified to be at or above that recommended for the type of location and work to be performed, including remote operations, in accordance with IES standards.
- h. Similar types of equipment which require operator monitoring shall be located in close proximity.
- i. Complex operator interactive equipment requiring operators to make interpretive judgments beyond their training levels shall be avoided.

#### 5.4 VALUE ENGINEERING CONSIDERATIONS

A value engineering assessment of the Conceptual Design was performed, which resulted in the conclusion that the design of the MCO handling crane and associated shielding cask was likely to be the most fruitful area to invest in optimizing. Accordingly, this key component was reevaluated, which subsequently led to the redesign of the Operating Area Bridge Crane and MCO Handling Machine (MHM) described in Section 2.4.

Other opportunities for application of Value Engineering may exist, and may be explored during Advanced Conceptual Design.

#### 5.5 DESIGN FOR RELIABILITY AND AVAILABILITY

To meet plant capacity requirements, the following concepts shall be utilized:

- a. Maximize equipment interchangeability.
- b. Locate complex components including electronic devices or those having a high probability of failure in contact maintenance areas.
- c. Operate power transmission devices below 75% of manufacturer's rating.
- d. Select pumps to operate in the middle of their flow and head range.
- e. Provide adequate equipment materials for the operating

- environment.
- f. Utilize commercially available equipment.
- g. Identify equipment repair methods and egress routes.
- h. Provide lag storage for process flow interruptions affected by maintenance.

#### 5.5.1 Design philosophy

Special design features to improve system reliability are added in cases where justified by life cycle cost considerations or where required by DOE or project criteria.

Reliability is the probability of a device or system performing its function adequately, for the period of time intended, under the operating conditions intended. The reliability of on-line systems is the primary design factor that determines the likelihood of an accident. Systems shall be designed with sufficient reliability to ensure an acceptable risk during the plant life. Risk is the product of the probability of an event that causes harm and the consequence of that event if it occurs.

Availability is a concept which applies to repairable systems, when productivity is a concern or when analyzing repairable standby systems that perform safety or environmental functions. Availability can be defined as the probability that a device or system is capable of performing its intended function adequately, at any given moment, under the operating conditions intended.

The benefits of improved reliability fall into two categories-improved safety and improved productivity. The cost of improved reliability is compared to the benefits of avoiding risk. There are at least three options for evaluating lost productivity at government facilities:

- 1) Actual cost of damage and penalties for failure to meet production schedules.
- 2) Capital cost of increasing the design production rate, for the purpose of compensating for increased downtime, to preserve the original time-averaged production rate.
- 3) Imputed cost, proportional to under-utilization of the capital investment in the facility. The installed capital cost will be about \$80 million, based on the Feasibility Study estimate.

#### 5.5.2 Criteria requirements

For safety class items and systems, the following requirements apply: higher quality, increased reliability, qualification to perform under Design Basis Accident conditions, and sufficient redundancy or diversity of design to assure that safety functions will not be prevented by single failures. Criteria for acceptable



radiological and toxicological risk are contained in the Hanford Safety Analysis Manual, WHC-CM-4-46. The risk guidelines are presented in the form of logarithmic-scaled plots of acceptable on-site and offsite exposure versus annual probability of occurrence.

### 5.5.3 Setting Priorities on System Reliability

The incentive for improving reliability is determined by the consequences of system failure. An evaluation of the major systems which contribute a significant risk to system availability included the vault structure, the operating area structure, vault passive ventilation, operating area ventilation, cask receiving, MCO handling, health protection, and utilities. The effects of system-level loss of function are shown in Table 5-2 and Table 5-3. The effects of out-of-range conditions at important design interfaces are given in Table 5-4. Events categorized as "Low" are not expected to occur in the 200 year life of the facility. Events categorized as "Medium" may be expected to occur once. The events that can threaten the integrity of the vault are already established as Design Basis Accidents, except for failure of the MCO relief device(s). Production-related events and ALARA worker exposure concerns can be evaluated on a cost-benefit basis during Advanced Conceptual Design.

## 5.6 DESIGN FOR MAINTENANCE AND INSPECTION

Maintainability features and guidelines for the different maintenance conditions shall be utilized as appropriate. For operating environments, equipment will be run to failure, removed, disposed, and replaced:

The design for such equipment shall include the following requirements.

- a. Locate higher failure rate assemblies so as to minimize replacement impact on other equipment.
- b. Be operable and/or serviceable by crane.
- c. Be positioned for visibility by plan view from remote viewing equipment.
- d. Be modularized where practicable.
- e. Consider temporary installations and services.
- f. Minimize the number and standardize, to the extent practicable, handling fixtures such as yokes, hooks, grapples, etc.
- g. Have legible identification.

For that equipment used in radioactive areas, but of such high value as to warrant decontamination and repair (e.g., cranes), the design includes the following requirements.

Table 5-2  
EFFECTS OF SYSTEM FAILURE

| SYSTEM                     | TYPE OF FAILURE        | CAUSES                                                     | EFFECT                                                      | LIKELIHOOD |
|----------------------------|------------------------|------------------------------------------------------------|-------------------------------------------------------------|------------|
| Vault Structure            | Major cracking.        | Seismic event.                                             | Loss of vault containment. MCO and vault temperatures rise. | Low.       |
| Operating Area Shelter     | Major deformation.     | Seismic event.<br>Crane accident.                          | Delay in moving MCOs, causing delay in unloading K-Basin.   | Low.       |
| Vault Passive Ventilation  | Obstructed air flow.   | Seismic event.<br>Volcanic ash.                            | MCO and vault temperatures rise.                            | Low.       |
| Operating Area Ventilation | Loss of air flow.      | Mechanical or control failure.<br>Loss of power.           | Workers evacuate. Delay in unloading K-Basin.               | Medium.    |
| Cask Receiving             | Unable to unload cask. | Mechanical or control failure.<br>Truck or train accident. | MCO temperature rises. Delay in unloading K-Basin.          | Medium.    |
| MCO Handling               | Unable to move MCO.    | Mechanical or control failure.<br>Crane mishap.            | MCO temperature rises. Delay in unloading K-Basin.          | Medium.    |
| Health Protection          | Monitor reads low.     | Electronic failure.                                        | Increased worker exposure.                                  | Medium.    |
|                            | Monitor false alarm.   | Monitor trouble or high rad.                               | Delay in unloading K-Basin.                                 | Medium.    |

Table 5-3  
EFFECTS OF UTILITY SYSTEM FAILURE

| SYSTEM                       | TYPE OF FAILURE                                       | CAUSES                                                       | EFFECTS                                                                                                              | LIKELIHOOD |
|------------------------------|-------------------------------------------------------|--------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|------------|
| Instrument Air               | Loss or low pressure.                                 | Mechanical or control failure. Maintenance mishap.           | HVAC and utility systems fail in safe conditions. Delay in unloading K-Basin.                                        | Medium.    |
| Sanitary and Process Water   | Loss or low flow.                                     | Loss of supply from 200E sanitary water. Maintenance mishap. | Cask washdown halted. Loss of instrument air. Delay in unloading K-Basin. Loss of ventilation coating.               | Medium.    |
| Fire Water                   | Failure to extinguish fire.                           | Control failure. Seismic damage.                             | Local damage to non-safety class items. Smoke blockage of HEPA filters.                                              | Low.       |
|                              | Flooded storage tubes.                                | Seismic damage to fire water in adjoining area.              | Thermal shock to MCOs. Negligible tube corrosion.                                                                    | Low.       |
| MCO Monitoring and Servicing | Failure to detect excess heat or hydrogen generation. | Abnormal MCO combined with faulty monitor instruments.       | MCO relief device opens, releasing contamination. Possible thermal damage to MCO and tube.                           | Low.       |
| Normal Electrical Power      | Outage.                                               | Fault within plant. Loss of outside power.                   | Loss of lighting, HVAC, Cask Receiving, & MCO Handling, Instrument Air (in long outage). Delay in unloading K-Basin. | Medium.    |
| Liquid Waste Collection      | Unable to accept flow.                                | Hold tank full, due to mechanical or control failure.        | Cask washdown halted. Delay in unloading K-Basin.                                                                    | Medium.    |

Table 5-4  
EFFECTS OF DEVIATION AT INTERFACES

| DESIGN INTERFACE                           | TYPE OF DEVIATION                       | CAUSES                                                 | EFFECT                                                           | LIKELIHOOD |
|--------------------------------------------|-----------------------------------------|--------------------------------------------------------|------------------------------------------------------------------|------------|
| MCO (contains inert gas and no free water) | Out-of-range weight or size.            | Poor quality control while filling MCOs.               | Minimal effect on MCO handling or cooling.                       | Low.       |
|                                            | Excessive radiation.                    | Variation in fuel. Poor quality control while filling. | Increased exposure to workers.                                   | Unknown    |
|                                            | Excessive heat rate.                    | Variation in fuel. Free water.                         | Increased MCO temperature.                                       | Unknown    |
|                                            | Slow inleakage of air during handling.  | Leaky valve. Flaw in MCO shell.                        | Increased MCO temperature.                                       | Low.       |
|                                            | Rapid inleakage of air during handling. | MCO relief device opens prematurely.                   | Increased MCO temperature and spread of contamination into area. | Low.       |
|                                            | Burst shell.                            | MCO relief device fails to open when needed.           | Same as above, and MCO stuck in cask, MHM, or tube.              | Low.       |
| Train with cask                            | Unknown.                                | Unknown.                                               | Unknown.                                                         | Unknown    |
| Truck with cask                            | Unknown.                                | Unknown.                                               | Unknown.                                                         | Unknown    |
| Piping Interfaces                          | Process variables out-of-range.         | Typical failures and errors.                           | Already considered in utility systems design.                    | Medium.    |

- h. Have protective coatings resistant to decontamination solutions.
- i. Minimize contamination traps such as ledges and crevices.
- j. Be modularized as practicable.
- k. Utilize standard fastening devices.
  - 1. To prevent galling, avoid stainless steel-to-stainless steel contact in fastening devices.
- m. Be capable of post-repair qualification.

For that equipment used in non-radioactive areas and contact maintained, the design includes the following requirements.

- n. Utilize standardized equipment and components.
- o. Position consumables for ease of access.
- p. Provide lay down and work space.
- r. Provide adequate lighting.
- s. Provide for safe isolation by mechanical separation, valving, or electrical disconnection.

Repair facilities. Adequate space for equipment maintenance and repair materials storage is provided in three areas: contaminated maintenance areas, electrical/instrument and mechanical rooms, MCO/Cask service area. The size options for the limited decontamination facilities should be reviewed to ensure all equipment can be decontaminated, inspected, or repaired.

#### 5.6.1 Maintenance planning

Preventative maintenance shall receive primary focus when undertaking facility maintenance planning.

#### 5.6.2 Mockups for training

The SNF CSB provides space for mockups for training aimed at reducing radiological exposure and easy repair or replacement of components.

#### 5.6.3 Support equipment

The SNF CSB shall provide support equipment located and sized to facilitate work.

### 5.7 DESIGN FOR TESTING

Pre-operation and startup testing of the SNF CSB shall be planned and conducted to assure proper performance of components and subsystems individually, and as part of overall facility performance.

A startup team, consisting either of in-house personnel or a qualified sub-contractor, will be assembled to assist the

operations staff prepare SNF CSB acceptance test procedures, calibrate equipment, and perform grooming and alignment. Operations will provide the Operating Safety Requirements based on the SNF CSB Safety Analysis Report and accompanying safety analyses. Operations staff will conduct a formal Operational Readiness Review that will be performed in conjunction with a Readiness Review performed by the Spent Nuclear Fuel Project Office. All facilities and systems will be operated to the maximum extent for anticipated operations. Final procedures will be validated by procedure walkthroughs and simulated operations prior to their use.

## 5.8 OPERATIONAL PHILOSOPHY

The safety of the public and the worker, and the protection of the environment shall be the primary considerations in the startup and operation of the SNF CSB. Startup and operations shall maintain the SNF CSB within its safety authorization basis and shall be conducted in full compliance with applicable Federal, State, and local laws and regulations. Operations are to be conducted efficiently. A primary goal shall be to have no lost-time accidents.

### 5.8.1 Operations Concept

K-Basin SNF shipments may be continuous (24 hour per day) and require multi-shift operation, although at present, a shipment rate of 2 MCO/day is anticipated. The expected duration of K-Basin shipments is about two years. The activities to remove the SNF from the K-Basin and transfer it to the SNF CSB have the highest priority to alleviate the risk of further ground water contamination associated with continued storage of SNF in the K-Basins.

Throughout the staging mode of operations the MCOs will require cooling, monitoring, venting, and purging. In general, staging mode operations will be conducted with direct visual access and with personnel wearing the appropriate protective clothing. Permanent or temporary shielding and the appropriate distance are utilized to reduce personnel exposure to as low as reasonably achievable. The operation of cranes and rigging equipment will be required. The operating staff will be housed adjacent to the main facility in temporary structures.

While the SNF is being processed in the stabilization facility, the SNF CSB will be incrementally re-configured for interim storage. In the interim storage mode of operations the SNF CSB receives MCOs containing processed SNF, provides interim storage of the MCOs until their final disposition has been determined and the long-term repository is available, and stages the MCOs for transfer to their final disposition. Interim storage mode operations will be similar

to those in the staging mode and are expected to last forty years. The SNF CSB is expected to be benign with periodic monitoring. Other than monitoring, the only operations would be responses to off-normal events such as a leak in an overpack. Operations personnel would be minimal and would be housed in adjacent facilities.

## 5.9 DESIGN FOR DECONTAMINATION & DECOMMISSIONING

### 5.9.1 Criteria for Decontamination.

Finishes for decontamination shall be in accordance with DOE Order 6430.1A, *General Design Criteria* (DOE 1989).

Special wall coatings that can be easily decontaminated shall be used on the walls, floors, and ceilings in other areas where infrequent decontamination is required.

### 6.9.2 Criteria for Decommissioning

Guidance for a design that facilitates eventual decommissioning shall be obtained from ANSI-N300-1975, *Design Criteria for Decommissioning of Nuclear Fuel Reprocessing Plants*. The principles listed below shall be employed to the extent practicable.

- a. Filters shall be placed as near as practical to the source of contamination to minimize contamination of ductwork.
- b. Areas subject to contamination shall be designed to facilitate decontamination. Liners and coatings shall be selected to withstand decontaminating agents and radiation degradation throughout the life of the plant.
- c. Storage vault penetrations shall be designed to minimize technical and construction problems in the structural closing and sealing of these penetrations during decommissioning.
- d. Penetrations shall be waterproofed for protection during decontamination.
- e. Fixtures and outlets shall be sealed.
- f. Floors shall be monolithic, nonporous, and sloped toward drains.
- g. Drains and similar piping shall have physical provisions for cleaning.
- h. Piping systems shall be sloped and free of traps except as required for process isolation.
- i. Adequate overhead clearance shall be provided for remote transfer of equipment over installed piping.
- j. Aisles shall be wide enough to facilitate movement of equipment.

## 6.0 SAFETY, REGULATORY COMPLIANCE AND PERMITTING

### 6.1 NRC EQUIVALENCY GOAL

#### 6.1.1 Facilities Authorization Basis

In addition to meeting all applicable DOE requirements, the SNF CSB will be designed, constructed, and operated to modern industry standards promulgated for new facilities having equivalent functions within the commercial nuclear industry.

#### 6.1.2 Accident Radioactive Releases

The SNF CSB will be designed, constructed, and operated such that after a design basis accident, potential exposure to radiation shall be within regulatory requirements, as specified in applicable section of 10 CFR 72.

#### 6.1.3 General Safety Equivalency

In addition to meeting other requirements applicable to the SNF CSB, the SNFP Regulatory Requirements Team has indicated that the SNF CSB will be required to demonstrate nuclear safety equivalency to Nuclear Regulatory Commission requirements for SNF storage facilities.

### 6.2 SAFETY ANALYSIS

#### 6.2.0 References

1. Westinghouse Hanford Co., "Spent Nuclear Fuel Project Canister Storage Building Preliminary Safety Evaluation," WHC-SD-SNF-PSE-002, Revision 0, July 24, 1995
2. Westinghouse Hanford Co., Safety Analysis Manual, WHC-CM-4-46, Section 9.0, "Safety Classification of Structures, Systems, and Components," Revision 1, May 17, 1995
3. US Department of Energy, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public," DOE/EH-0070, July 1988
4. US Department of Energy, "Internal Dose Conversion Factors for Calculation of Dose to the Public," DOE/EH-0071, July 1988
5. Westinghouse Hanford Co., "Performance Specification for the Spent Nuclear Fuel Canister Storage Building," WHC-SD-SNF-FRD-014, Draft Revision A, May 17, 1995



### 6.2.1 Nuclear Criticality Safety

Nuclear criticality safety of the SNF in the CSB was addressed in the Staging and Storage Facility Feasibility Study Final Report, dated May 1995. Based on the Feasibility Study conservative criticality analysis, it was concluded that there is no criticality concern related to the storage of the K-Basin N-Reactor fuel elements in the MCOs and/or in the CSB storage tubes even under the worst-case conditions. Nothing in the Conceptual Design of the SNF CSB has changed that would impact that conclusion.

### 6.2.2 Preliminary Hazards Analysis

An updated Preliminary Hazards Analysis (PHA) for the SNF CSB is documented in Reference 1. The Architect Engineer (A/E) participated as a member of the team that developed this PHA. This PHA qualitatively classifies all hazards identified to date for the SNF CSB Conceptual Design into frequency and consequence categories. All credible scenarios (frequency equal to or greater than  $1E-6$ /year) identified in the PHA are addressed either in the accident analysis of Reference 1 or in Section 6.2.4 below.

### 6.2.3 Safety Classification Evaluation

#### 6.2.3.1 Safety Class Criteria

##### 6.2.3.1.1 Criteria for Safety Class 1

Safety Class 1 structures, systems, and components are those whose failure and/or malfunction during normal, abnormal, or accident conditions described in the safety analysis of Section 6.2 could meet any of Criteria 1 through 8 in Table 1 of Reference 2.

##### 6.2.3.1.2 Criteria for Safety Class 2

Safety Class 2 SNF CSB structures, systems, and components are those not defined as Safety Class 1 whose failure and/or malfunction during normal, abnormal, or accident conditions described in the safety analysis of Section 6.2 could meet any of Criteria 9 through 15 in Table 1 of Reference 2.

##### 6.2.3.1.3 Criteria for Safety Class 3

Safety Class 3 SNF CSB structures, systems, and components are those not defined as Safety Class 1 or 2 whose failure and/or malfunction during normal, abnormal, or accident conditions described in the safety analysis of Section 6.2 could meet Criteria 16 in Table 1 of Reference 2.

#### 6.2.3.2 Safety Classification Methodology

In accordance with Reference 2, SNF CSB structures, systems, and components shall be assigned to one of the above classes according to the above criteria and methodology, which are based on the potential consequence of failure. Items that fall into more than one class shall be assigned to the highest applicable class. Note that the WHC safety classification system and categories are not used to implement Safety Classes 1, 2, and 3 in DOE Order 6430.1A, *General Design Criteria* (1989), "Abbreviations and Glossary" section. The terminology "Safety Class" or "Safety Class Item" as used in Doe Order 6430.1A is equivalent to and applies only to WHC Safety Class 1.

#### 6.2.4 Design Basis Accidents

This section, along with Reference 1 of Section 6.2, documents the results of a Design Basis Accident (DBA) analysis for the SNF CSB Conceptual Design. These two documents describe the safety design basis of the SNF CSB Conceptual Design, including the basis for determination of required Safety Class (SC) SSCs.

A spectrum of candidate accident scenarios is postulated. Included are scenarios required to be addressed by programmatic requirements and additional scenarios identified by the Preliminary Hazards Analysis (PHA) documented in Reference 1 of Section 6.2. All postulated scenarios are addressed: All scenarios except Natural Phenomena Hazards (NPH) are addressed in Reference 1 of Section 6.2. A summary of the results of Reference 1 is shown in Section 6.2.4.3 below. All NPH scenarios are addressed in the following sections of this report.

The frequency and radiological consequences for each DBA are calculated for the SNF CSB Conceptual Design. The SNF CSB is located on the site of the HWVP CSB (10,750 meter reduced site boundary distance).

These frequencies and consequences are compared with the onsite and offsite radiological dose limits of Reference 2 of Section 6.2. Where unmitigated consequences exceed the dose limit for the estimated frequency, mitigating SSCs are designated as SC-2 or SC-1 as appropriate. Credit is taken for the operability of these SSCs to mitigate the consequences of the DBA to within the applicable dose limit.

The frequency-dependent dose limits of Reference 2 of Section 6.2 include the following:

##### A. Offsite

1. Accident frequency of  $>1E-2$  to  $\geq 1E-1$ /year: 5 mSv

2. Accident frequency of  $>1E-4$  to  $\leq 1E-2$ /year: 50 mSv
3. Accident frequency of  $>1E-6$  to  $\leq 1E-4$ /year: 25 mSv
4. Undetermined accident frequency: 5 mSv

B. Onsite

1. Accident frequency of  $>1E-2$  to  $\geq 1E-1$ /year: 50 mSv
2. Accident frequency of  $>1E-4$  to  $\leq 1E-2$ /year: 250 mSv
3. Accident frequency of  $>1E-6$  to  $\leq 1E-4$ /year: 1000 mSv
4. Undetermined accident frequency: 50 mSv

Reference 2 of Section 6.2 also specifies similar limits for exposure to non-radiological toxicological releases. The SNF CSB Conceptual Design, however, does not use significant quantities of toxicologically hazardous materials. No credible DBA scenarios involving such hazardous materials have been identified.

6.2.4.1 NPH DBA Methodology

6.2.4.1.1 Event Consequences

The methodology described in DOE-STD-1027-92 is used for this analysis of NPH DBAs for the SNF CSB Conceptual Design. The following equation, from page A-6 of DOE-STD-1027-92, describes the basic method used to calculate the offsite/onsite dose for each NPH DBA:

$$\text{MOI Dose} = (\text{MAR}) (\text{RF}) (\text{X/Q}) (\text{RR}) (\text{SA}) (\text{CEDE}) \quad (1)$$

$$\text{or: (Source Activity) (CEDE) (RF) (X/Q) (RR)} \quad (1a)$$

where

MOI Dose - Maximum Offsite (or Onsite) Individual Dose [mSv]

MAR - Material at Risk [grams]; RF - Release Fraction [Unitless]

RR - Respiration Rate [ $\text{m}^3/\text{sec}$ ]; SA - Specific Activity [Ci/g]

X/Q - Atmospheric dispersion factor [ $\text{sec}/\text{m}^3$ ] for the receptor distance

CEDE - Committed Effective Dose Equivalent [mSv/Ci] per curie inhaled

Source Activity = (MAR) (SA) [Ci]

#### 6.2.4.1.2 Initiating Event Frequencies

Formal quantitative calculation of event frequencies is not included in this assessment. The estimated frequencies listed in Results Table 6-2 in section 6.2.4.3 are based on the frequency categories shown in the PHA in Reference 1 of Section 6.2.

As stated in the assumptions below, the frequencies of several scenarios are assumed to be below the threshold of credibility, based on the assumed outcomes of future, more detailed safety analyses. These assumptions should be verified or changed in later phases of the design of the SNF CSB, based on the results of these analyses.

#### 6.2.4.1.3 Scenario Development/Screening

The first step in the NPH DBA analysis process is a screening process to justify eliminating from consideration all scenarios that are not DBAs. Remaining as DBAs are those scenarios that meet both of the following criteria:

- A. The scenario is "credible:" The frequency of occurrence of the initiating event is equal to or greater than  $1\text{E-}6/\text{year}$ . Accidents with frequencies less than this threshold are considered to be "beyond the design basis," or "not credible." This credibility threshold is defined in Section 1300-1.4.2 (and the Glossary) of DOE Order 6430.1A. The basic credibility threshold of  $1\text{E-}6/\text{year}$  is modified by DOE-STD-1021 for NPH events to  $1\text{E-}5/\text{year}$ . Accidents beyond the design basis, or "residual risk," will be analyzed in later phases of the design as required by DOE Order 5480.23.
- B. The scenario is the limiting, or highest consequence, accident in its type: For example, the (credible) earthquake with the most severe consequence is the "design basis earthquake." If the plant is designed to mitigate the risk of the design basis earthquake to within the dose limits, then it also can mitigate adequately all earthquakes of lesser severity.

#### 6.2.6.1.4 Material At Risk Estimates

All spent fuel received at the SNF CSB will be contained in Safety Class 1 Multi-Canister Overpacks (MCOs). For the purposes of this assessment, Material At Risk (MAR) is assumed to be the "maximum" inventory of radionuclides in each MCO, taken from the "MCO Description" contained in Section 1.0, times the number of MCOs at risk in each accident scenario.

Failure of a MCO containing the "maximum" radionuclide inventory would cause a release and a resultant dose that can be calculated. The theoretical inhalation dose that would result from uptake of

the entire contents of a MCO (immersion dose for Kr-85) is calculated. This dose is the "peak inhalation Committed Effective Dose Equivalent (CEDE) at the source." The method of calculation of this dose source term is described below.

#### 6.2.4.1.5 Source Terms

Equation (1a) shown in the Methodology section above can be restated as follows:

$$\text{MOI Dose} = \frac{[(\text{Source Activity [in curies]}) (\text{CEDE})]}{[(\text{RF}) (\text{X/Q}) (\text{RR})]}$$

$$\text{or} = [\text{Inhalation CEDE at the source}] [K]$$

where:

$$[\text{Inhalation CEDE at the Source}] = (\text{Source Activity}) (\text{CEDE}) \quad (2)$$

$$\text{and} \quad K = (\text{RF}) (\text{X/Q}) (\text{RR})$$

The "K" part the dose calculation is independent of the nuclear characteristics of the source MAR. Inhalation CEDE at the source, on the other hand, is completely characteristic of the each nuclide making up the source term.

In fact, the RF (1E-3 for all isotopes except Kr-85) and RR (3.5E-4 m<sup>3</sup>/sec) and meteorology all are assumed to be fixed for the SNF CSB by DOE-STD-1027-92. The CSB site boundary distance (10,750 meters) fixes X/Q for the SNF CSB as well, as described below.

Equation 1 is intended to be used to calculate the dose caused by one source radionuclide at a time. The inventory of a MCO comprises several isotopes as listed given in the "MCO Description" referred to above.

The dose that would result from a failed MCO containing this mixture of isotopes actually would comprise the sum of the individual doses contributed by each isotope present in the mixture at the time of release:

$$(\text{Inhalation CEDE of the mixture}) = \sum_i (\text{Source Activity})_i (\text{CEDE})_i$$

The (Source Activity)<sub>i</sub> values used in this analysis are taken from the Section 1.0, "MCO Description". The CEDE<sub>i</sub> values are taken from References 3 and 4 of Section 6.2.

#### 6.2.4.1.6 Release Modeling

As stated above, the release model used for this analysis is taken from DOE-STD-1027-92. The Release Fraction (RF) used for each scenario is  $1E-3$  (except for noble gases such as Kr-85, which have an RF of 1). Respiration rate (RR) of the receptor used for each scenario is  $3.5E-4$  m<sup>3</sup>/sec. Both are bounding values taken from DOE-STD-1027-92, page A-7.

The offsite receptor distance for the SNF CSB is 15,000 meters. The onsite receptor distance is 100 meters from the release point for ground level releases or at the location of maximum dose for elevated releases.

| Receptor Location                                   |                    | Release Elevation          | ** Atmospheric Dispersion Factor X/Q [sec/cubic meter] |
|-----------------------------------------------------|--------------------|----------------------------|--------------------------------------------------------|
| Offsite Boundary                                    | 15,000 meters East | Ground Level (Unmitigated) | 7.13E-6                                                |
|                                                     |                    | Elevated* (Mitigated)      | 6.05E-6                                                |
| Onsite (Facility Boundary or point of maximum dose) | 100 meters South   | Ground Level (Unmitigated) | 1.13E-2                                                |
|                                                     | 250 meters South   | Elevated* (Mitigated)      | 1.71E-5                                                |

\* Effective stack height at least 2.5 times building height

\*\* Atmospheric dispersion factors (X/Q values) used for the offsite and onsite receptor distances are taken from Reference 1

Table 6-1

#### 6.2.4.2 Assumptions

##### 6.2.4.2.1 Initiating Event Frequency/Credibility

- A. The Fire Hazards Analysis (FHA) for the SNF CSB has been deferred to a later stage of the design, when more design details become available. Refer to Section 6.2.6 below. Specific information necessary for the FHA is not available at this time, such as the combustible loadings in the backup

generator and UPS battery areas, and the amounts and rates of production of  $H_2$  gas produced by MCOs both prior to arrival and during storage in the tubes. When the FHA is performed, it will address these and other fire/explosion related issues in accordance with DOE/NRC requirements.

For the purposes of this analysis, fire/explosion is assumed not to be a credible initiating event anywhere in this facility (i.e., cause a radioactive release, or failure of safety class 1 or 2 SSCs). Similarly, fire/explosion as a dependent event (e.g., caused by a DBE) is assumed not to be a credible event.

The basis for these assumptions is qualitative at this early phase of the design. As stated above, the FHA has not been performed. For several reasons, however, there is a level of confidence that the FHA will result in a detailed facility configuration that will support this assumption by preventing the introduction of significant combustibles into the facility, by preventing fires and explosions, and by providing the capability to detect, suppress and prevent the spread of fires.

Historically, SNF storage facilities such as the SNF CSB have posed a substantially lower fire risk than other types of facilities such as reactors and radiochemical processing plants. Normal combustible loadings are at insignificant levels throughout most of the SNF CSB. Review of chemical usage in the facility generally shows minimal use of combustible chemicals.

Process Engineering has reviewed the rates and amounts of hydrogen releases from MCOs during normal operation. At the rate of once-through ventilation planned for the operating deck, hydrogen concentrations will stay several orders of magnitude below flammable limits above grade. Even after an extended loss of ventilation (not considered credible) it would take several days for concentrations to reach flammable levels. This could be prevented merely by opening exterior doors to the wind.

Periodic purging of the tube during normal operation will prevent the buildup of hydrogen to dangerous levels. Even if hydrogen levels did reach flammable levels in the annulus between the storage tube and storage tube and stored MCOs, there is no ignition source in the tube during normal operations.

There are, however, a few issues identified to date that could bear on the validity of this assumption and should be addressed in detail by the FHA:

1. The capability should be provided for an adequate, timely response to a possible fire resulting from the failure of a MCO.
2. If diesel generators and/or batteries are used for backup electrical power, then the fire risk associated with this equipment should be addressed.
3. The FHA should consider the fire risks associated with any use of liquid nitrogen inside the SNF CSB, such as the condensation and reevaporation of oxygen from the surrounding atmosphere.
4. If hydrogen gas or other explosive gases or liquids would be used in the facility, the source containers preferably should be located outside the SNF CSB, far enough away so that leakage and explosion involving all the stored gas would not be a credible threat to the SNF CSB structures.
5. If any such gases are brought into the facility via permanently installed tubing, then the tubing from the storage bottle should be provided with Safety Class 1 isolation valves. These valves must close automatically on high seismic acceleration.
6. If a bottles of such gases are transported into (the vicinity of) SNF CSB structures, then the frequency and consequences of the resultant hazard should be limited:
  - a) The capacity of the bottles should be minimized, and
  - b) The amount of time the bottle is in the facility should be minimized.

The FHA should show that a fire or explosion capable of failing Safety Class 1 and 2 SNF CSB SSCs is not a credible event.

This assumption is key to this assessment. If it were invalid (i.e., if a substantial release due to a fire/explosion were credible inside the SNF CSB), then SC mitigation may be required to meet the dose limits. Substantial additional SC SSCs could be required. This change could affect the estimated capital cost of the facility significantly.

- B. Analysis of aircraft crash, as to both credibility (frequency) and consequences, is not included in this assessment (i.e., for purposes of this assessment, aircraft crash is assumed not credible). The extensive analysis already done for the HWVP



PSAR proves that this is the case, given that fact that helicopters no longer are used for security patrol at the Hanford Site.

#### 6.2.4.2.2 Event Consequences

- A. Loss of ventilation due to equipment failure or power failure is not considered to be a DBA initiating event because it causes no release by itself, and requires no mitigation by permanently installed SSCs. In later stages of the design, the effects of these and other equipment failures will be considered in the design of SC SSCs, when taken as single failures in addition to DBA initiating events, as required to meet the single failure criterion of DOE Order 6430.1A, WHC-CM-4-46 and IEEE 379.
- B. It is assumed that SNF CSB SC SSCs will be designed to withstand the effects of the site-specific Design Basis Earthquake (DBE), Design Basis Wind (DBW), and Design Basis Ashfall without causing an offsite dose exceeding the applicable limit, as required by DOE-STD-1021-92. This assumption is reflected in the capital cost estimates herein. To provide an analytical basis for incurring the capital cost of complying with this assumption, the unmitigated dose consequences that could result if this assumption were not true are calculated and include in Table 6-2.
- C. It is assumed that only one MCO or cask will be moved at a time during any loading, unloading, servicing or inspection activity.
- D. As stated in Reference 5 of Section 6.2, the SNF CSB site has been determined to be outside the maximum extent of the Hanford Site design basis flood. For this reason, Design Basis Flood is not included as a DBA for the SNF CSB..

#### 6.2.4.3 Results

##### 6.2.4.3.1 Scenario Screening Results

Table 6-2 shows the results of the scenario screening process used to determine which scenarios are considered DBAs applicable to each phase of the SNF CSB Conceptual Design.

##### 6.2.4.3.2 Material At Risk/Source Terms

Table 6-2 also shows the MAR quantities/source terms for each DBA.

TABLE 6-2  
SAFETY ANALYSIS RESULTS SUMMARY

| Analysis Documented in | DBA No. | Initiating Event Scenario                                  | Source Term | Offsite: Unmitigated/Mitigating Limiting Dose [mSv] | Onsite: Unmitigated/Mitigating Limiting Dose [mSv] | Estim. Freq. [Yr <sup>-1</sup> ] | S.C. 1 and 2 SSCs Required*                                                                                                                       |
|------------------------|---------|------------------------------------------------------------|-------------|-----------------------------------------------------|----------------------------------------------------|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| PSE                    | 1       | MCO overpressurization/rupture                             | Single MCO  | 1.4/0.85/5                                          | 3,500/1.8/50                                       | 1E-1 to 1E-2                     | SC 2 Emerg. Ventil. Exhaust Filtration System with a flowrate of 11.37 cubic meters/sec (24,000 cfm) and a stack height of 36.6 meters (120 feet) |
| PSE                    | 2       | MCO failure due to drop/human error                        | Single MCO  | 0.61/0.33/5                                         | 620/9.4/50                                         | 1E-1 to 1E-2                     |                                                                                                                                                   |
| PSE                    | 3       | Stacking 3rd MCO in wrong tube/MCO drop w/o impact limiter | Two MCOs    | 1.2/0.66/5                                          | 1,200/19/50                                        | 1E-1 to 1E-2                     |                                                                                                                                                   |
| CDR                    | 4       | Design Basis Earthquake                                    | 750 MCOs    | 3.42E4/0/50                                         | 5.65E7/0/250                                       | 2E-4                             | SC 1 Structures only                                                                                                                              |
| CDR                    | 5       | Design Basis Wind                                          | 750 MCOs    | 3.42E4/0/50                                         | 5.65E7/0/250                                       | 2E-4                             | SC 1 Structures only                                                                                                                              |
| CDR                    | 6       | Design Basis Ashfall                                       | 750 MCOs    | 3.42E4/0/50                                         | 5.65E7/0/250                                       | 2E-4                             | SC 1 Structures, ash handling equipment on air intakes                                                                                            |
| CDR                    | 7       | Design Basis Power Failure                                 | None        | 0/0/50                                              | 0/0/250                                            | 1E-2                             | None; Power not required for passive cooling system                                                                                               |

\* WHC Safety Class 1 (DOE Safety Class) if the Offsite Limit applicable to the event frequency is exceeded by the unmitigated dose; WHC Safety Class 1 (DOE Safety Class and Performance Category 3) if the Offsite Limit applicable to the event frequency is exceeded by the unmitigated dose.

#### 6.2.4.3.3 Unmitigated Doses/Facility Hazard Category

Table 6-2 also shows the unmitigated offsite and onsite dose consequences for each DBA. Dose consequences are compared with the frequency dependent onsite and offsite dose limits of Section 6.2.4 above.

As Table 6-2 shows, the total quantity of MAR present in the SNF CSB makes the facility DOE Hazard Category 2, the same category as the K-Basins and the remainder of SNFP activities. This same conclusion is reached in Reference 1 of Section 6.2.

#### 6.2.4.3.4 Safety Classifications

Where unmitigated offsite consequences exceed the applicable dose limit, credit must be taken for the operability of WHC SC-1 (DOE Safety Class) SSCs to prevent or mitigate the consequences of the DBA to within the limit. When credit is taken for the SC-1 SCCs shown in Table 6-2, offsite consequences are less than the dose limits for all DBAs analyzed, given the assumptions on which the analyses are based.

Similarly, where unmitigated onsite consequences exceed the applicable dose limit, credit must be taken for the operability of WHC SC-2 (DOE Non-Safety Class) SSCs to prevent or mitigate the consequences of the DBA to within the limit. When credit is taken for the SC-2 SCCs shown in Table 6-2, onsite consequences are less than the onsite limits for all DBAs analyzed, again given the assumptions on which the analyses are based.

Tables 6-2 and 6-3 show the SC-2 and SC-1 SSCs required for the SNF CSB design to meet the onsite and offsite dose limits.

##### 6.2.4.3.4.1 Structures/Performance Categories

Because the SNF CSB is DOE Hazard Category 2 per Reference 1 of Section 6.2, because some of the structures listed in Table 6-3 provide DOE Safety Class (WHC SC-1) protection against natural phenomena hazards, these structures are candidates for designation as Performance Category 3 as defined in DOE Order 5480.28, and DOE-STD-1021.

Other structures listed in Table 6-3 provide WHC SC-2 protection against natural phenomena hazards. These structures are Performance Category 2 as defined in DOE Order 5480.28, and DOE-STD-1021.

TABLE 6-3  
SNF CSB CONCEPTUAL DESIGN  
SAFETY CLASS 1 AND 2 STRUCTURES, SYSTEMS, AND COMPONENTS

| System Name                                                        | S.C.                     | Safety Class Function                                                                                                         | Prevents/Mitigates These DBA's                                                                   |
|--------------------------------------------------------------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| <b>STRUCTURES<br/>(PASSIVE SYSTEMS)</b>                            |                          |                                                                                                                               |                                                                                                  |
| Vault structure (Floor, exterior & interior walls, operating deck) | 1                        | S.C. 1: MCO cooling, confinement, protection of MCO from Natural Phenomena Hazards (NPH);<br>S.C. 2: MCO confinement, cooling | S.C. 1: DBE, DBW, DB Ashfall<br>S.C. 2: MCO drop, MCO Overpressurization (rupture disc ruptures) |
| Vault passive cooling system intakes                               | 1                        | MCO cooling, protection from NPH                                                                                              | DBE, DBW, DB Ashfall                                                                             |
| Vault passive cooling system exhaust stack                         | 1                        | MCO cooling, protection from NPH                                                                                              | DBE, DBW, DB Ashfall                                                                             |
| Tubes                                                              | 1                        | S.C. 1: MCO cooling, confinement, protection of MCO from Natural Phenomena Hazards (NPH);<br>S.C. 2: MCO confinement, cooling | S.C. 1: DBE;<br>S.C. 2: MCO drop, MCO Overpressurization                                         |
| Operating area structure (assuming deck-mounted gantry crane)      | 1*<br>See Note "A" below | S.C. 1*: Protection from NPH (won't fall onto and fail the operating deck structure)<br>S.C. 2: MCO confinement               | S.C. 1*: DBE, DBW, DB Ashfall;<br>S.C. 2: MCO drop, MCO Overpressurization                       |

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Fluor Daniel, Inc.  
Government Services  
Contract 04436307

TABLE 6-3  
SNF CSB CONCEPTUAL DESIGN  
SAFETY CLASS 1 AND 2 STRUCTURES, SYSTEMS, AND COMPONENTS  
(Continued)

| System Name                                              | S.C. | Safety Class Function                                                                                                                                                                     | Prevents/Mitigates These DBA's                                |
|----------------------------------------------------------|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
| Operating area crane (structure only)                    | 1*   | S.C. 1*: Prevent MCO/cask drop (that fail the operation from NPH structure), protection from NPH (crane won't fall onto and fail the operating deck structure)<br>S.C. 2: MCO confinement | S.C. 1*: DBE, DBW<br>S.C. 2: MCO drop, MCO Overpressurization |
| Operating area emergency exhaust system stack            | 2    | S.C. 2: MCO confinement                                                                                                                                                                   | S.C. 2: MCO drop, MCO Overpressurization                      |
| Cask unloading area structure                            | 2    | S.C. 2: MCO confinement                                                                                                                                                                   | S.C. 2: MCO drop, MCO Overpressurization                      |
| Cask unloading area crane (structure only)               | 2*   | S.C. 2*: Prevent cask/MCO drop, protection from NPH (crane won't fall onto and fail the operating deck structure)                                                                         | S.C. 2*: DBE                                                  |
| S.C. 1, 2 HVAC rooms structures                          | 2    | S.C. 2: MCO confinement                                                                                                                                                                   | S.C. 2: MCO drop, MCO Overpressurization                      |
| Backup generator, UPS, & switchgear/MCC rooms structures | 2    | S.C. 2: MCO confinement                                                                                                                                                                   | S.C. 2: MCO drop, MCO Overpressurization                      |
| Control room structures                                  | 2    | S.C. 2: MCO confinement                                                                                                                                                                   | S.C. 2: MCO drop, MCO Overpressurization                      |
|                                                          |      |                                                                                                                                                                                           |                                                               |

TABLE 6-3  
SNF CSB CONCEPTUAL DESIGN  
SAFETY CLASS 1 AND 2 STRUCTURES, SYSTEMS, AND COMPONENTS  
(Continued)

| System Name                                                                                                                             | S.C. | Safety Class Function                                                     | Prevents/Mitigates These DBA's                 |
|-----------------------------------------------------------------------------------------------------------------------------------------|------|---------------------------------------------------------------------------|------------------------------------------------|
| <b>SYSTEMS (ACTIVE)</b>                                                                                                                 |      |                                                                           |                                                |
| Operating area/cask unloading area emergency HVAC exhaust systems (2) (fans/motors, filters, ducting, sensing, actuation, and controls) | 2    | S.C. 2: MCO confinement                                                   | S.C. 2: MCO drop, MCO Overpressurization       |
| Operating area/cask unloading area emergency HVAC exhaust stack radiation monitoring systems (2)                                        | 2    | S.C. 2: Monitor releases post-accident, alarm on incipient filter failure | S.C. 2: MCO/Cask drops, MCO Overpressurization |
| Backup generator systems (2)                                                                                                            | 2    | S.C. 2: MCO confinement                                                   | S.C. 2: MCO drop, MCO Overpressurization       |
| Backup UPS systems (2)                                                                                                                  | 2    | S.C. 2: MCO confinement                                                   | S.C. 2: MCO drop, MCO Overpressurization       |
| Backup AC power distrib. systems (2)                                                                                                    | 2    | S.C. 2: MCO confinement                                                   | S.C. 2: MCO drop, MCO Overpressurization       |
| Backup DC power distrib. systems (2)                                                                                                    | 2    | S.C. 2: MCO confinement                                                   | S.C. 2: MCO drop, MCO Overpressurization       |
| Backup generator, UPS, switchgear rooms HVAC systems (2)                                                                                | 2    | S.C. 2: MCO confinement                                                   | S.C. 2: MCO drop, MCO Overpressurization       |
| Control area HVAC systems (2)                                                                                                           | 2    | S.C. 2: MCO confinement                                                   | S.C. 2: MCO drop, MCO Overpressurization       |
|                                                                                                                                         |      |                                                                           |                                                |

TABLE 6-3  
 SNF CSB CONCEPTUAL DESIGN  
 SAFETY CLASS 1 AND 2 STRUCTURES, SYSTEMS, AND COMPONENTS  
 (Continued)

| System Name       | S.C. | Safety Class Function                                          | Prevents/Mitigates These DBA's           |
|-------------------|------|----------------------------------------------------------------|------------------------------------------|
| <b>COMPONENTS</b> |      |                                                                |                                          |
| Facility cask     | 1*   | S.C. 1*: Won't fall onto and fail the operating deck structure | S.C. 1: DBE                              |
|                   |      | S.C. 2: MCO confinement                                        | S.C. 2: MCO drop, MCO Overpressurization |

Note A: "1\*" means "Safety Class 1\*", also referred to as 2/1, or 3/1. A Safety Class 1\* item is defined as one whose structural failure could prevent a Safety Class 1 SSC from adequately performing its safety function by damage through physical interaction. Structural requirements applied to "1\*" items are less stringent than those applied to Safety Class 1 items. A similar relationship holds for Safety Class 2 and Safety Class 2\* items.

#### 6.2.4.3.4.2 Systems

Table 6-3 shows the WHC SC-2 systems required for the SNF CSB. As this table also shows, there are no non-structure-related SC-1 systems required for the SNF CSB.

#### 6.2.5 Preliminary Hazards Evaluation

As stated above, the Preliminary Safety Evaluation for the SNF CSB Conceptual Design is documented in Reference 1 of Section 6.2.

#### 6.2.6 Fire Hazards Analysis

The Fire Hazards Analysis is based on the Design Basis Fire Analysis used on the Hanford Waste Vitrification Plant for the HWVP Canister Storage Building. The format was being modified at the time that the project was halted, however the conclusions reached will be followed. The main hazard in the HWVP Canister Storage Building was a contained fuel transporter with large rubber tires which is not used in this facility. The remainder of the building is very similar to the currently proposed conceptual design. A final Fire Hazard Analysis will be performed during Advanced Conceptual Design which will take into account the problems anticipated due to accident scenarios caused by uranium hydrides present in the K-Basin fuel. This will include the design basis fire in accordance with ANSI N290 8.3.1 requirements.

### 6.3 OCCUPATIONAL SAFETY & HEALTH

The SNF CSB is designed such that worker exposures to occupational safety hazards are within regulatory requirements of the DOE, the Federal OSHA, the State of Washington, and WHC. These requirements are listed in Reference 5 of Section 6.2

### 6.4 REGULATORY COMPLIANCE AND PERMITTING

#### 6.4.1 Nuclear Orders/Directives/Regulations

DOE Orders will provide the regulatory design basis for the SNF CSB facility, and other technical requirements, such as NRC regulations, will be included as necessary to comply with all required regulatory concerns.

##### 6.4.1.1 DOE Orders

DOE Order 6430.1A, General Design Criteria, is the primary design criteria document for the SNF-CSB. Division 13, Special Facilities, Section 1300, General Requirements, contains most of the requirements applicable to the design of the SNF-CSB. Other DOE Orders that directly impact the design include the following:



|               |                                                                           |
|---------------|---------------------------------------------------------------------------|
| DOE 5400.5    | Radiation Protection of the Public and Environment.                       |
| DOE 5480.4    | Environmental Protection, Safety, and Health Protection Standards         |
| DOE 5480.7A   | Fire Protection                                                           |
| DOE 5480.11   | Radiation Protection for Occupational Workers                             |
| DOE 5480.24   | Nuclear Criticality Safety                                                |
| DOE/EV1830-T5 | A Guide to Reducing Radiation Exposure to as Low as Reasonably Achievable |
| SNF-RD-PM-001 | Spent Nuclear Fuel Program Requirements Document                          |

#### 6.4.1.2 Design Criteria

The draft Performance Specification for the SNF CSB, WHC-SD-SNF-FRD-014, Rev. A, contains a number of other federal, state and WHC codes that apply to the design of the SNF CSB. Included in these are NRC regulations such as 10 CFR 72; the NRC equivalency of the SNF CSB design is addressed in Section 6.1.

#### 6.4.1.3 ANSI 57.9 (NRC)

The intent of ANSI 57.9 (1992), "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)" is to specify the minimum NRC design requirements for such an installation.

ANSI 57.9 covers both performance and design requirements for an independent spent fuel storage installation (ISFSI) in the following categories: transportation package handling area; fuel unit handling area; fuel unit transfer area; storage area; heating, ventilation, and air conditioning (HVAC); buildings; radwaste treatment; electrical power, instrumentation and control (I&C) and communications; fire protection; physical protection; accountability; nuclear criticality safety; radiological protection; decommissioning; quality assurance; interfaces for an ISFSI located on an existing nuclear facility site; and structural design. Some of these systems are applicable only to particular storage concepts. The requirements are fairly detailed with about 90 performance requirements (Section 5 of ANSI 57.9) and about 390 specific design requirements (Section 6 of ANSI 57.9).

The present intent is to examine the compliance of the design requirements in ANSI 57.9 during the Advanced Conceptual Design phase of the program.

#### 6.4.1.4 SAR Requirements

Permission to construct the SNF CSB will be based on an updated version of the Preliminary Safety Evaluation, Reference 2.2, which will be used as a PSAR substitute for the SNF CSB Project.

The SNF CSB FSAR will satisfy the requirements of DOE Order 5480.23, "Nuclear Safety Analysis Reports." To accomplish this, the format and content of FSAR for the SNF CSB will be in accordance with DOE Standard 3009-94, "Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports." WHC will retain overall responsibility for preparation of the FSAR. WHC and the A/E will share production responsibility for the individual chapters of the FSAR.

#### 6.4.2 Non-Nuclear Orders/Directives/Regulations

##### 6.4.2.1 NEPA Compliance

The strategy for NEPA compliance on the SNF CSB is contained in WHC-SD-SNF-SP-001, Rev. D. The Path Forward is based upon a series of interim NEPA actions in advance of the completion of the Hanford Site EIS. These interim actions will include the removal, transportation and interim storage of K Basin fuel in the SNF CSB facility, and are considered allowable for independently justified safety considerations. Future decisions on the final disposition of the SNF will be based upon the EIS Record of Decision.

##### 6.4.2.2 Air Emissions/Permits

Air emissions regulations that establish design criteria are contained in WAC 173-400, "General Regulations for Air Pollution Sources," WAC 173-460, "Controls for New Sources of Toxic Air Pollutants" and WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides;" in addition, regulations for filing air permits are contained in WAC 173-401, "Operating Permit Regulation." These are the State of Washington versions of the Federal Clean Air Act.

The PSD (Prevention of Significant Deterioration) emission limitations are found in WAC 173-400-141, and specific limitations on emission of criteria pollutants exist. These limits include the following:

|                                                    |               |
|----------------------------------------------------|---------------|
| Oxides of nitrogen, NO <sub>x</sub>                | 40 tons/year  |
| Sulfur dioxide, SO <sub>2</sub>                    | 40 tons/year  |
| Carbon monoxide, CO                                | 100 tons/year |
| Ozone                                              | 40 tons/year  |
| Lead                                               | 0.6 tons/year |
| Particulate Matter (PM <sub>10</sub> )             | 15 tons/year  |
| Fluorides                                          | 3 tons/year   |
| Sulfuric Acid Mist, H <sub>2</sub> SO <sub>4</sub> | 7 tons/year   |
| Total Reduced Sulfur                               | 10 tons/year  |

Toxic emission requirements and applicability are in WAC 173-460-030, new source review requirements are in WAC 173-460-040, and requirements to quantify emissions are in WAC 173-460-050.

Airborne radionuclide emission standards are in WAC 246-247-040 and maximum permissible radionuclide emissions are in WAC 173-480-050.

#### 6.4.2.3 RCRA Non-applicability

The K-Basin fuel and in-container sludge is classified as "spent nuclear fuel" and not as an EPA waste; WHC document WHC-SD-SNF-SP-001, Rev. D, "Spent Nuclear Fuel Project (SNFP) Regulatory Strategy," provides the guidance on this issue.

Since the SNF is not an EPA waste, it cannot be classified as a hazardous waste. As such, the SNF is not subject to either the RCRA requirements for hazardous wastes contained in 40 CFR 260 to 280 or the WAC (Washington Administrative Code) requirements in WAC 173-303, "Dangerous Waste Regulations." Thus, none of the design requirements in these codes apply to the SNF CSB.

#### 6.4.2.4 Storm Water and Sanitary Sewer Permits

Both storm water and sanitary sewer permits will be required for the SNF CSB Facility, but neither of these are expected to have cost or schedule impacts.

## 7.0 CONCLUSIONS AND RECOMMENDATIONS

### 7.1 CONCLUSIONS

The Conceptual Design of the SNF CSB further developed the initial design concepts and results produced in the earlier Staging and Storage Facility Feasibility Study and Canister Storage Building Trade Study.

The Conceptual Design was refined to incorporate updated functional and operational criteria for the facility. The project purpose and key result areas which were defined as essential to successfully achieving the program mission were identified and served as a basis for the further development of the design concept.

The SNF CSB Conceptual Design presented in this report demonstrates that the construction of the SNF CSB can take advantage of the existing HWVP CSB site preparation, excavation, and base mat and wall construction. Other features of the existing facility design can also be adaptable with minimal effort. However, caution must be used in applying current HWVP CSB design information directly to the SNF CSB. Several criteria changes are currently being evaluated, including seismic and shielding requirements, as well as an open issue regarding future use of the empty, third vault which will not have storage tubes installed.

The Conceptual Design served as the technical basis for preparing a "bottoms up" cost estimate which would confirm the economic viability of the project and facilitate the key decision process for proceeding with detailed design and construction.

Furthermore, the Conceptual Design also identified cost drivers and engineering options which can meet the "design to cost" objectives of the project. Section 3.5 provides a description of the proposed options and total estimated cost (TEC) reductions.

Finally, the Conceptual Design identified technical areas which require further resolution for the upcoming Advanced Conceptual Design phase in order to support the fast track schedule milestones to start Detailed Design in October, 1995; to start construction in December 1995; and to receive spent nuclear fuel by December 1997.

### 7.2 RECOMMENDATIONS

It is recommended that further refinement and evaluation of the Conceptual Design be performed during Advanced Conceptual Design (ACD) to ensure cost, schedule and safety requirements are achieved.

The following areas of technical concern which require further resolution during ACD were identified.

- . Future use of the empty vault for cesium and strontium storage, as well as construction timing and methodology.
- . Decision regarding the possible re-racking of Spent Nuclear Fuel.
- . Establish criteria for demonstrating NRC equivalency.
- . Seismic criteria resolution, including the development of response spectra and damping values conforming to NRC.
- . Relaxation of the requirement to extend the service life of the facility structure to 200 years.
- . To demonstrate cost effectiveness in the successful construction of the SNF CSB, consistent with performance requirements, pursue the various "design to cost" reduction options identified. Section 3.5 provides a description of the proposed options and associated total estimated cost (TEC) reductions, Figure 3-9.
- . Shielding and occupational dose criteria and Radiation Access Zones (RAZ) exposure requirements based on ALARA analysis. DOE regulations (10CFR835 Subpart K) imposes design requirements on new facilities in terms of maximum allowable occupational doses. The combination of orders and regulations prevents designers from making allowances for temporary shielding or administrative controls normally provided by operations forces. A decision is needed as to whether these restrictions on the CSB design do not come into effect until 100% of the MCOs are placed in the storage tubes and the facility begins storage operations. This is particularly impactful to the Load-In/Load-Out area of the facility.
- . Evaluation of mobile HVAC, monitoring and electrical systems on the crane to mitigate storage tube loading/unloading accident scenarios and minimize operating area contamination.
- . Eliminate the capability to receive rail shipments of MCOs from K-Basins if not necessary.
- . Venting of the MCOs in the SNF CSB prior to installation in storage tubes, as well as open MCO vent valves during the SNF staging process.
- . Interface information regarding the transport cask, including weight, dimensions, configuration, i.e. top versus bottom loaded, and shielding performance.

- . Waste water collection requirements, including the exportation to the Treated Effluent Disposal Facility (TEDF) in 200-E via an on-site sample building.
- . Update and issue the Performance Specification
- . Preparation of a comprehensive schedule integrating engineering, procurement and construction to identify critical path activities.
- . Initiation of specific preliminary analysis and design calculations, i.e. seismic, shielding and HVAC, to support fast track detailed design and construction schedules.
- . The possibility of advanced procurement of services and materials associated with the vault walls and carbon steel storage tubes is currently under review. Advanced procurement would allow an early FY'96 start to the vault wall construction. However, caution is advised prior to making such a management decision and assuming the associated risks prior to completing sufficient calculations to validate those decisions.

Currently, seismic criteria is being re-evaluated. Vault walls, storage tube design and base mat storage tube anchorage could be affected by seismic criteria changes. A determination on the use of the empty vault could have profound implications on the vault wall design and shielding requirements.

Until criteria and facility use decisions are made, early procurement of materials is not recommended. It is suggested; however, that pre-qualification of construction contractors and vendors be performed in advance of Detailed Design and start of construction using the original HWVP CSB documents as the basis.

## 8.0 REFERENCES

The design and construction of the SNF CSB shall be in accordance with the regulations, orders, directives, codes, and standards listed in this Section.

### CODE OF FEDERAL REGULATIONS (CFR):

1. 10 CFR 72; Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste
2. 10 CFR 435; Energy Conservation Voluntary Performance Standards for New Buildings; Mandatory for Federal Buildings
3. 10 CFR 830.120 Quality Assurance Requirements

### U.S. DEPARTMENT OF ENERGY (DOE):

4. DOE Order 5400.5; Radiation Protection of the Public and the Environment (1990)
5. DOE Order 5480.4; Environmental Protection, Safety, and Health Protection Standards (1994)
6. DOE Order 5480.7A; Fire Protection (1993)
7. DOE Order 5480.11; Radiation Protection for Occupational Workers (1988)
8. DOE Order 5480.23; Nuclear Safety Analysis Reports
9. DOE Order 5480.24; Nuclear Criticality Safety (1992)
10. DOE Order 5484.1; Environmental Protection, Safety, and Health Protection Information Reporting Requirements (1981)
11. DOE Order 6430.1A; General Design Criteria (1989)
12. DOE-STD-3009-94; Preparation Guide for U.S. Department of Energy Non-reactor Nuclear Facilities Safety Analysis Report (1994)
13. DOE/EH-0070; External Dose-Rate Conversion Factors for Calculation of Dose to the Public (July 1988)
14. DOE/EH-0071; Internal Dose Conversion Factors for Calculation of Dose to the Public (July 1988)
15. DOE/EV/1830-T5A; Guide to Reducing Radiation Exposure to As Low As Reasonably Achievable (1980)

16. DOE/EH-0256T; Radiological Control Manual, Rev. 1 (April 1994)
17. SNF-RD-PM-001; Spent Nuclear Fuel Program Requirements Document (October 1994)

**DOE RICHLAND OPERATIONS (RL):**

18. DOE-RL-HPS-SDC-4.1; Standard Architectural-Civil Design Criteria, Design Loads for Facilities; Rev 12 (1993)
19. DOE-RL-HPS-SDC-5.1; Heating, Ventilating, and Air-Conditioning (1979)
20. DOE-RL-HPS-157-M; Standard Specification for Fire- and Moisture-Resistant Nuclear Grade HEPA Filters; (Rev. 1, 1986)
21. DOE-RL Order 4320.2C; Site Selection (1990)
22. DOE-RL Order 5300.1C; Telecommunications (1992)
23. DOE-RL Order 5480.11A; Requirements for Radiation Protection (1986)
24. DOE-RL Order 6430.1C; Hanford Plant Standards Program (1990)
25. HSRCM-1; Hanford Site Radiological Control Manual (TBD)

**WESTINGHOUSE HANFORD COMPANY (WHC):**

26. WHC-CM-1-3; Management Requirements and Procedures;
27. MRP 5.46; Safety Classification of Systems, Components, and Structures (1991)
28. WHC-CM-4-3; Industrial Safety Manual (1988)
29. WHC-CM-4-46; Nonreactor Facility Safety Analysis Manual (1995)
30. WHC-CM-7-5; Environmental Compliance (1988)
31. WHC-EP-0063; Hanford Radioactive Solid Waste Packaging, Storage, and Disposal Requirements (1988)
32. WHC-EP-0830; Hanford Spent Nuclear Fuel Project Recommended Path Forward (October 1994)
33. WHC-SD-GN-303; Backup Electrical Power System Definitions and Design Criteria



34. WHC-SD-SNF-FRD-014; Performance Specification for the Spent Nuclear Fuel Canister Storage Building (Draft Rev. A, May 17, 1995)
35. WHC-SD-SNF-PSE-002; Spent Nuclear Fuel Project Canister Storage Building Preliminary Safety Evaluation (Rev. 0, July 24, 1995)
36. WHC-SD-SNF-SP-001 Rev. D; Spent Nuclear Fuel Project (SNFP) Regulatory Strategy

#### **CODES AND STANDARDS:**

37. ANSI 57.9; Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)
38. ANSI C2-1990; National Electrical Safety Code (NESC)
39. ANSI/IEEE 308-1980; Criteria for Class 1E Power Systems for Nuclear Power Generating Stations
40. ANSI/IEEE 379-1988; Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety
41. ANSI/IEEE 384-1981; Criteria for Independence of Class 1E Equipment and Circuits
42. ASME NOG-1; Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder) (1989)
43. ASME NQA-1; Quality Assurance Program Requirements for Nuclear Facilities (1994)
44. ASME N509-1989; Nuclear Power Plant Air Cleaning Units and Components
45. ASHRAE 52-1976; Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter
46. NFPA 70-1993; National Electrical Code (NEC)
47. NFPA 101-1994; Life Safety Code

#### **THE STATE OF WASHINGTON**

48. WAC 173-400; General Regulations for Air Pollution Sources
49. WAC 173-401; Operating Permit Regulation

- 51. WAC 173-480; Ambient Air Quality Standards and Emission Limits for Radionuclides
- 52. WAC 48-54; Public Water Supplies (1990)

**OTHER PUBLICATIONS:**

- 53. Fluor Daniel, Inc.; Canister Storage Building Trade Study Final Report, May 1995
- 54. Fluor Daniel, Inc.; Staging and Storage Facility Feasibility Study Final Report, February 1995
- 55. MIL-STD-1472D; Human Engineering Design Criteria for Military Systems, Equipment, and Facilities (1989)
- 56. PNL 6577; Health Physics Manual of Good Practices for Reducing Exposure to Levels that are as Low as Reasonably Achievable (ALARA); Munson; 1988
- 57. US Nuclear Regulatory Commission, CR-5542, Models for Estimation of Service Life of Concrete Barriers in Low-Level Radioactive Waste Disposal, September 1990.
- 58. Report of Geotechnical Investigation, Proposed Hanford Waste Vitrification Plant, Hanford, Washington prepared by Dames & Moore for Kaiser Engineers Job No. 10805-383-016, November 15, 1989, with supplements.

## LIST OF APPENDICES

- I. OUTLINE SPECIFICATIONS
- II. EQUIPMENT LIST
- III. STRUCTURAL ENGINEERING CALCULATIONS
- IV. HVAC ENGINEERING DATA
- V. RADIATION PROTECTION ENGINEERING DATA
- VI. PROCESS ENGINEERING DATA
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## APPENDIX I

### Outline Specifications

Table I-A lists specification sections that are expected to be provided for the SNF CSB detailed design. Unless noted otherwise, the specification section will use the HWVP E350 specification section of the same number and title as a basis. If a section is to be used that was developed or issued for an HWVP design package other than E350, the package number is indicated in parentheses to the right of the subject title: (e.g., (A130)). If a section is to be used that will be newly created for the SNF CSB, it is designated (NEW). For some specification divisions, explanatory notes (identified as I-B through I-E) have been provided. These are noted next to the division title.

Table I-A

Outline of Technical Specifications

DIVISION 1 - GENERAL REQUIREMENTS

| Section | Title                          |
|---------|--------------------------------|
| 01730   | Operation and Maintenance Data |

DIVISION 2 - SITE WORK

| Section | Title                                     |
|---------|-------------------------------------------|
| 02220   | Excavation and Backfill                   |
| 02231   | Aggregates for Roads and Surfacing (A130) |
| 02452   | Railroad Track Work (A180)                |
| 02510   | Asphaltic Concrete Paving (A130)          |
| 02720   | Storm Drainage (A130)                     |
| 02830   | Steel Chain Link Security Fence (A140)    |
| 02831   | Steel Chain Link Fence (A140)             |

DIVISION 3 - CONCRETE (See Explanatory Notes I-B, Note 1)

| Section | Title                                               |
|---------|-----------------------------------------------------|
| 03200   | Concrete Reinforcement                              |
| 03252   | Concrete Anchors                                    |
| 03300   | Cast-In-Place Concrete                              |
| 03346   | Ready-Mixed Concrete Production and delivery (A900) |
| 03350   | Concrete Sealer and Hardener (B265A)                |
| 03361   | Shotcrete (A130)                                    |
| 03362   | Insulating Concrete                                 |
| 03600   | Grout                                               |

## DIVISION 5 - METALS

| Section | Title                              |
|---------|------------------------------------|
| 05060   | Welding Structural                 |
| 05062   | Welding Piping                     |
| 05063   | Welding Pressure Vessels (P33B)    |
| 05066   | Welding Specialty Equipment (P33B) |
| 05067   | Welding HVAC Systems               |
| 05120   | Structural Steel                   |

## DIVISION 7 - THERMAL AND MOISTURE PROTECTION

| Section | Title                    |
|---------|--------------------------|
| 07200   | Insulation               |
| 07465   | Metal Wall System        |
| 07500   | Membrane Roofing System  |
| 07600   | Flashing and Sheet Metal |
| 07730   | Roof Hatches             |
| 07900   | Sealants                 |

## DIVISION 8 - DOORS AND WINDOWS

| Section | Title                  |
|---------|------------------------|
| 08110   | Metal Doors and Frames |
| 08305   | Access Doors           |
| 08365   | Telescoping Doors      |
| 08700   | Finish Hardware        |

## DIVISION 9 - FINISHES (See Explanatory Notes I-B, Notes 2 & 3)

| Section | Title                             |
|---------|-----------------------------------|
| 09100   | Metal Stud Framing System         |
| 09250   | Gypsum Board                      |
| 09300   | Ceramic Tile                      |
| 09651   | Resilient Sheet Flooring          |
| 09800   | Special Coatings (B265A)          |
| 09900   | Painting                          |
| 09940   | High Performance Coatings (B265A) |

## DIVISION 10 - SPECIALTIES

| Section | Title              |
|---------|--------------------|
| 10200   | Metal Wall Louvers |
| 10800   | Toilet Accessories |

## DIVISION 13 - SPECIAL CONSTRUCTION

| Section | Title                                                                                  |
|---------|----------------------------------------------------------------------------------------|
| 13088   | Canister/Overpack - Storage Tube Assemblies                                            |
| 13089   | Canister/Overpack - Floor Plug                                                         |
| 13090   | Shielding Windows and Accessories (P020)                                               |
| 13091   | Railroad Tunnel Vertical Shield Door (P05A)                                            |
| 13092   | Window Guards and Window Shields (P020)                                                |
| 13096   | Canister/Overpack - Floor Plug Embeds                                                  |
| 13098   | Canister/Overpack - Storage Impact Absorbers                                           |
| 13099   | Canister/Overpack - Storage Tube Installation                                          |
| 13252   | Precautions for Fabrication, Handling and Storage of Stainless Steel and Nickel Alloys |
| 13432   | Pressure Vessels - Carbon Steel (P220)                                                 |
| 13XXX   | Cranes (NEW)                                                                           |
| 13XXX   | Transfer Cart (NEW)                                                                    |
| 13XXX   | Storage Rack (NEW)                                                                     |
| 13XXX   | RR Car Moving Device (NEW)                                                             |
| 13XXX   | Shielding Floor Gates (NEW)                                                            |
| 13XXX   | Cask Entrance Hatch (NEW)                                                              |
| 13XXX   | Cask Lid Unbolting Device (NEW)                                                        |
| 13XXX   | Cask Lid Grapple (NEW)                                                                 |
| 13XXX   | Lifting Yokes (NEW)                                                                    |
| 13XXX   | MCO Handling Device (NEW)                                                              |

## DIVISION 15 - MECHANICAL (See Explanatory Notes I-C)

| Section | Title                                                                                            |
|---------|--------------------------------------------------------------------------------------------------|
| 15010   | HVAC Basic Requirements                                                                          |
| 15061   | Piping Material, Fabrication, Erection and Pressure Testing (Carbon Steel, Iron and Nonmetallic) |
| 15141   | Centrifugal Pumps (P33B)                                                                         |
| 15145   | Sump Pumps (P33B)                                                                                |
| 15152   | Plant and Instrument Air Compressors (P220)                                                      |
| 15196   | Identification and Tagging Methods for Mechanical Equipment                                      |
| 15200   | Vibration Isolation Devices                                                                      |
| 15258   | Thermal Insulation for Ductwork and Piping                                                       |
| 15400   | Plumbing                                                                                         |
| 15501   | Automatic Wet Pipe Sprinkler System                                                              |
| 15760   | Unit Heaters - Electric                                                                          |
| 15771   | Air Conditioning Units                                                                           |

|       |                                    |
|-------|------------------------------------|
| 15782 | Air Handling Units                 |
| 15820 | Vacuum Blowers                     |
| 15832 | Miscellaneous Fans (HVAC)          |
| 15836 | Electric Duct Heaters              |
| 15840 | Ductwork                           |
| 15861 | Dampers                            |
| 15868 | HVAC HEPA Filters & Plenums (NEW)  |
| 15870 | Air Distribution Devices           |
| 15880 | Instrument Air Dryer System (P220) |
| 15883 | Air Filters (HVAC)                 |
| 15990 | HVAC System Testing and Balancing  |
| 15XXX | Storage Tanks (NEW)                |
| 15XXX | Pumps (NEW)                        |

**DIVISION 16 - ELECTRICAL (See Explanatory Notes I-D)**

| Section | Title                                         |
|---------|-----------------------------------------------|
| 16100   | Electrical Installation                       |
| 16110   | Electrical Materials and Devices              |
| 16143   | Uninterruptible Power Supply System           |
| 16150   | Motors - Induction                            |
| 16610   | Electrical Requirements for Package Equipment |
| 16905   | Electrical Testing                            |
| 16XXX   | CCTV (NEW)                                    |

**DIVISION 17 - CONTROLS AND INSTRUMENTATION (See Explanatory Notes I-E)**

| Section | Title                                                                            |
|---------|----------------------------------------------------------------------------------|
| 17601   | Temperature Transmitters - Electronic                                            |
| 17605   | Room Thermostats - Electronic                                                    |
| 17612   | Thermowells and Resistance Temperature Detectors                                 |
| 17612W  | Thermowells and Resistance Temperature Detectors                                 |
| 17614   | Thermowells Resistance Temperature Detectors,<br>Canister Storage Building Vault |
| 17615   | Differential Pressure Transmitters - Electronic                                  |
| 17626   | Pressure Gauges                                                                  |
| 17630   | Mass Flowmeters                                                                  |
| 17630W  | Mass Flowmeters                                                                  |
| 17656   | Globe Type Control Valves                                                        |
| 17664   | Vacuum Relief Valves                                                             |
| 17667   | Pressure Switches                                                                |
| 17669   | Flow Switches                                                                    |
| 17696   | Humidity Transmitter - Electronic                                                |
| 17697   | Smoke Detectors                                                                  |
| 17703   | Instrument Piping Materials                                                      |
| 17704   | General Instrumentation Installation and Testing                                 |
| 17705   | Instrument Calibration and Checkout                                              |



- 17708 Instrument Piping Pressure Testing
- 17709 Instruments Furnished with Mechanical Equipment (P220)
- 17852 Plant and instrument Air Compressors and Air Dryers Control Panels (P220)
- 17864 Instrument Furnished with Mechanical

#### **Explanatory Notes I-B: Architectural**

1. The Metallic Topping Section 03010 (E350) is deleted due to the deletion of heavy Transporter on the main Operating Floor. This concrete floor will only receive a concrete sealer / hardener (see B265A Section 03350 Concrete Sealer and Hardener).
2. The rail Wash Down, Load-In/Load-Out floors and walls will receive special coatings similar to the rail area of the Vitrification Building Shipping/Receiving Area. The Regulated Change Area/Waste Handling and Radioactive Maintenance Area will also receive Special Coatings and High Performance Paint. These specification sections are from Section 09800 Special Coatings and Section 09940 High Performance Paint (B265A).
3. The below-grade MCO/Cask Transfer Tunnel will not be Stainless Steel lined but have a Special Coating similar to the HWVP Operating Corridor. See Section 09800 Special Coatings (B265A).

#### **Explanatory Notes I-C: Section 15061**

This set of notes discusses some differences from the E350 Section 15061 specification with the reasons for the changes:

1. Teflon Seals in Nitric Acid Decon

The type of decon solution to be used is not certain, so nitric acid has been listed in the specification as a possibility, and teflon seals are specified for resistance to nitric acid. Though teflon is among the least radiation resistant of polymers, Fluor Daniel experience is that contact maintained areas do not experience enough radiation to degrade it.

2. B7 Bolts and Carbon Steel Centering Rings Used With Stainless Steel in Non-Decon Areas

On previous Hanford Projects, B8 stainless steel bolts and stainless steel centering rings were specified. There is no reason for these outside of hot cell areas and contact maintained areas since other carbon steel materials are used there. They are considerably more expensive than B7 bolts and carbon steel centering rings, which are specified here.

### 3. Cast Iron UL Approved Valves in Firewater System

On HWVP, Hanford criteria required UL-approved components to be used in the Firewater System. The majority of these components are cast iron, which was initially prohibited during design, despite stress analysis showing that the stresses induced by the Design Basis Earthquake were within allowable limits for cast iron. Ductile iron and steel UL approved components were specified, but there are relatively few manufacturers of these. Procurement problems were experienced in the field, and after being given the background as to why these were specified, a field decision was made by WHC to accept cast iron components.

### 4. Polyethylene Wrapping of Iron Components

Polyethylene wrap per American Water Works Association Standard C105 is specified for iron components (valves, etc., on the plastic underground lines). This works by creating an oxygen starved region in the area between the iron and the soil, and has a long history of successful use. However, the WINCO interpretation of the HWVP TDP section on cathodic protection was that it was required for all metal buried components, so a sacrificial anode was placed at each valve.

Due to field modifications, however, limit switches were placed on several of the valves, making polarization by the sacrificial anodes impossible. The contractor's corrosion engineer (quite correctly) wrote a deviation request stating that cathodic protection was not required for these iron components in the first place. This deviation was field approved. Fluor Daniel suggests that the SNF CSB project avoid the unnecessary trouble of placing an anode at each valve and use the AWWA wrapping.

### Explanatory Notes I-D: Electrical

These notes are intended to identify the general requirements for the major electrical equipment and to provide a brief description of the equipment and quality level. The outline specifications also identify a manufacturer for reference.

#### 1. 480 Volt Switchgear:

The 480 volt switchgear shall be metal enclosed with power circuit breakers. The switchgear shall be designed, tested and constructed in accordance with ANSI C37.20.1 and NEMA SG-5. The circuit breakers shall be drawout type in accordance with NEMA SG-3, and ANSI C37.13, C37.16 and C37.17. The switchgear shall comply with UL 1558 and each cubicle shall bear the UL mark. The switchgear shall be specified as service entrance per the NEC. The switchgear bus shall be copper. The switchgear shall be provided with metal barriers between cable compartments and main bus and the breaker

cubicles shall be provided with grounded metal shutters to block the primary disconnects when the breaker is withdrawn. Switchgear shall be manufactured by Siemens, Westinghouse or equal.

2. 480 Volt MCCs:

Motor control centers shall be manufactured in accordance with NEMA standard ICS 2-322 and meet the requirements of UL 845. Each vertical section and unit shall bear the UL mark. MCCs shall utilize drawout combination motor starters. The main bus compartment shall be isolated from the top horizontal wireway. Vertical bus shutters shall be provided to cover the bus when a plug-in starter or feeder is withdrawn. MCC's shall be manufactured by Allen Bradley, GE or equal.

3. UPSs:

UPSs shall comply with UL 1778 and shall have a total harmonic distortion rating of 5% or less (within computer manufacturer guidelines). The UPSs shall be provided with the following features:

- Battery cabinet and batteries for 15 minute operation
- Battery charger
- Inverter
- Static Switch
- Bypass features

The single phase units shall be manufactured by Topaz or equal and the three phase units shall be manufactured by EPE Technologies or equal.

4. Automatic Transfer Switches:

Automatic transfer switches shall comply with UL 1008 and meet the requirements of NFPA 110, 99 and 70. The switches shall be provided with bypass-isolation switch to avoid load interruption during routine maintenance. The switches shall be open transition type. Automatic transfer switches shall be manufactured by ASCO or equal.

5. Pad Mounted Transformer:

The three phase pad mounted transformer shall comply with ANSI standards C57.12.26, C57.12.00, C57.12.70, C57.12.80 and C57.90. The transformer shall be provided with the following options:

- |                                    |                                |
|------------------------------------|--------------------------------|
| - Liquid level gage                | - Drain Valve                  |
| - Vacuum Pressure gage             | - ANSI tank ground pads        |
| - Automatic pressure relief device | - external lightning arrestors |

- Elbow valve arrestor
- Loop Feed

Pad mounted transformer shall be manufactured by GE or equal.

#### 6. Diesel Generators:

Diesel generators shall be skid mounted 80 kW units, complete with day tank, batteries, control panel and output breaker, Onan or equal.

#### Additional Reference Specifications:

- Motor Control Centers, HWVP Package P27A
- Area Security Lighting, HWVP Package A150
- Temporary Construction Power, HWVP Package A170, Division 16

#### Explanatory Notes I-E: Controls and Instrumentation

The following is a draft outline specification for Distributed Control Systems (DCS):

##### Part 1 - General

##### 1.01 Description

This specification covers the technical requirements for the Distributed Control System (DCS) to be installed at the Spent Nuclear Fuel Canister Storage Building (SNF CSB) at Hanford, Washington.

The DCS shall be provided with all hardware, software, documentation, engineering, and specialty equipment required to provide a fully operational DCS.

##### 1.02 Scope

The following components form an integral part of the DCS and are the major components in the system.

- Operator's console to be located in the SNF CSB control room. The console shall house one or more CRTs, keyboards, and plant communication equipment
- Alarm printer
- Report printer
- Emergency shutdown control and handswitches
- Remote Terminal Units (RTU)
- Highway Interface Units (HIU)

### 1.03 Quality Assurance

#### A. Reference Standards:

##### American National Standards Institute (ANSI)

Ansi 10.3 Guidelines for the Documentation of Digital Computer Programs

Ansi 10.4 Guidelines for the Verification and Validation of Scientific and Engineering Computer Programs for the Nuclear Industry

##### Department of Energy Standards

DOE 6430.1A General Design Criteria

##### Institute of Electrical and Electronic Engineers (IEEE)

IEEE 730 Standard for Software Quality Assurance Plans

IEEE 983 Guide for Software Quality Assurance Planning

##### Military Standards

MIL.STD 1472D 1989 Human Engineering Design Criteria for Military Systems, Equipment and Facilities

##### National Electrical Manufacturers Association (NEMA)

NEMA ICS-6 Enclosures for Industrial Controls and Systems

NEMA 250 Enclosures for Electrical Equipment (1000 volt max.)

##### International Conference of Building Officials (ICBO)

UBC Uniform Building Code, 1988 Edition

##### National Fire Protection Association (NFPA)

NFPA-70 1990 National Electric Code

#### B. U.S. Nuclear Regulatory Commission

NUREG/OR-4227 Human Engineering Guidelines for the Evaluation and Assessment of Video Display Units

### 1.04 Site Conditions

#### Environmental :

All DCS equipment will be installed indoors and shall meet the following :

- Operating Temperature: 60°F to 104°F
- Storage Temperature: 60°F to 104°F
- Relative Humidity: TBD
- Altitude: 708 feet

All DCS equipment shall be suitable for installation in a Seismic Zone TBD as defined by the Uniform Building Code, 1988 edition. The equipment shall be certified to remain structurally intact through an earthquake when installed in the stated zone.

## Part 2 - Products

### 2.01 Description

The DCS shall provide monitoring, alarming, data logging, and limited supervisory control for the SNF CSB process, HVAC and Health Protection Systems (HPS).

#### A. Redundancy:

The DCS shall be capable of supporting redundant I/O hardware for critical control and monitor loops. All redundant components shall be provided with fault detection and auto-transfer to the back-up component.

#### B. Equipment:

##### Operator's Console - Qty: 1 ea.

Operator's console shall have 2 ea. CRTs with individual keyboards. The current configuration is to use 1 CRT to monitor and control the Process units, HVAC units, and utilities, and 1 CRT for software configuration and graphics development.

CRT displays shall be high resolution 19" color monitors.

CRTs shall have the capability to monitor and control any of the systems displayed on any of the CRTs., i.e., all CRTs shall be capable of full interchangeability.

##### Alarm and Report Printers

One each alarm and report printer shall be provided. The printers shall have the capability of backing each other such that alarms and reports can be supported on one printer. Alarms shall have priority over reports when only one printer is available, (i.e., alarm messages shall have the capability of interrupting reports). When two printers are available, one shall be dedicated to alarms and the other shall be dedicated to reports.

##### Shutdown control/handswitches

A control panel shall be provided console to provide alarm and shutdown functions in an emergency. The monitor and control functions shall be hardwired and completely separate from the DCS

system. Pushbutton handswitches shall be provided to perform the following functions: TBD

#### Remote Terminal Units (RTU)

RTUs are input output (I/O) cards that interface field devices to the DCS. RTUs shall have the capability to be clustered together in a common operating area (rack room) or distributed remotely throughout the plant. The current configuration is to have remote units distributed throughout the vault and utility areas of the plant. One RTU shall be required for vault area and one RTU will be required for the utility systems and the HVAC systems. Total number of RTU units required is 2 ea.

#### Highway Interface Units (HIU)

HIUs shall be provided to interface to the Hanford LAN and the HP system. The HIUs interface communication protocols to the DCS protocol for communication compatibility.

#### C. Communications

A redundant data highway shall be provided to communicate between the RTUs, operator's console, local control panels, Hanford Site LAN and the HPS. The data highways shall be the vendors standard communication hardware and be installed in separate conduits with routing to provide maximum security.

#### D. Software

The DCS contractor shall provide all software required for configuration and operation of the DCS. The software shall be the vendor's standard-off-the shelf packaged software and no custom software shall be provided. The software packages shall provide the following functions:

- Configuration of the database
- Graphic display generation
- Process and HVAC control
- Alarm generation
- Hourly, daily, weekly, monthly report generation
- Trending capability
- Interface communication to other systems provided by others
- Internal alarm and self diagnostics to monitor integrity of the DCS

#### E. Performance Specification

The DCS shall be capable of providing the following performance requirements:

- Refresh rate: the DCS shall update process data within 30 sec. or sooner under all conditions.
- Memory : the DCS shall have sufficient memory to provide trend and report data for up to 30 days.
- Backup control: auto switchover shall be bumpless with no change in operating parameters.
- Communications: continuous monitoring of the communications link with peripheral modules will be maintained. In the event of a communications failure, switchover to the redundant highway shall be automatic with no loss of data.

F. I/O Point Count: TBD

G. Display Format

- Graphic display of entire CSB
- Graphic display of each vault
- Graphic display of utility system
- Overview display of HVAC system
- Graphic display of individual air handling units

H. Report Format: TBD

I. Training

DCS operator training is to be provided by selected vendor. Configuration and logic/interlock training shall be provided at vendor facility. Vendor to provide one week hands-on training at the Hanford site.

J. Documentation

The DCS system shall be completely documented with installation and maintenance instruction. A startup spare parts list as well as a recommended spare parts list for 1 year's operation shall be provided. Maintenance and instruction manuals shall be provided for each of the plug-in interchangeable modules for the system.

K. Space and Expansion Capability

DCS rack space shall allow for 30% spare channel expansion capability. Spare channels shall be wired out to I/O terminal blocks, however the plug-in cards shall not be installed. The existing plug-in cards shall have 20% spare channels for startup growth.

L. Factory and Field Acceptance Test

The DCS shall be wired out to simulated I/O points and demonstrated at the Factory Acceptance Test to be performed at the vendors facility. The DCS shall be completely operational with all



displays and report generation operational at the time of this test demonstration. A second test shall be performed at the Hanford job site to verify that the system is in good working operation after shipment to the job site and installation in the control room.

## APPENDIX II

- A. Equipment List
- B. Long-Lead Procurement List

SNF CSB Conceptual Design Report  
 Westinghouse Hanford Company  
 WHC P.O. TVW-SVV-370252

Fluor Daniel, Inc.  
 Government Services  
 Contract 04436307

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ATTACHMENT A  
 SNF SNF CSB EQUIPMENT LIST

| DESCRIPTION                   | EQUIPMENT ID | CAPACITY                   | PHYSICAL SIZE | MATERIAL | POWER  | WBS | COMMENTS | PROCUREMENT | SC |
|-------------------------------|--------------|----------------------------|---------------|----------|--------|-----|----------|-------------|----|
| Storage Tubes, MCO            | (440 ea)     |                            |               |          |        | 230 |          | Early       |    |
| Storage Tubes Overpack        | (12 ea)      |                            |               |          |        | 230 |          | Early       |    |
| Floor Plug Embed,<br>Standard | (660 ea)     |                            |               |          |        | 230 |          | Early       |    |
| Floor Plug Embed,<br>Overpack | (17 ea)      |                            |               |          |        | 230 |          | Early       |    |
| Air-Cooled Condensing<br>Unit | ACC-1        | 4.8 x 10 <sup>5</sup> BTUH |               |          | 50 KW  | 260 | Standby  |             | 4  |
| Air-Cooled Condensing<br>Unit | ACC-2        | 4.8 x 10 <sup>5</sup> BTUH |               |          | 50 KW  | 260 | Standby  |             | 4  |
| Air Cooled Condensing<br>Unit | ACC-3        | 60,000 BTUH                |               |          | 7 KW   | 240 |          |             | 4  |
| Air Washer                    | AHU-1        | 20,000 CFM                 |               |          | 30 HP  | 260 |          |             | 4  |
| Air Washer                    | AHU-2        | 20,000 CFM                 |               |          | 30 HP  | 260 |          |             | 4  |
| Kr OSA Purge                  | AHU-3        | 9,000 CFM                  |               |          | 75 HP  | 260 |          |             |    |
| Heating                       | AHU-3        | 7.1 x 10 <sup>5</sup> BTUH |               |          | 208 KW | 260 |          |             |    |
| Air Handling Unit "A"         | AHU-4A       | 11,000 CFM                 |               |          | 15 HP  | 260 |          |             | 4  |
| DX Cooling                    | AHU-4A       | 4.8 x 10 <sup>5</sup> BTUH |               |          |        |     |          |             |    |
| Heating                       | AHU-4A       | 85,400 BTUH                |               |          | 25 KW  |     |          |             |    |
| Air Handling Unit "B"         | AHU-4B       | 11,000 CFM                 |               |          | 55 KW  | 260 | Standby  |             | 4  |
| DX Cooling                    | AHU-4B       | 4.8 x 10 <sup>5</sup> BTUH |               |          |        | 260 | Standby  |             | 4  |

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SNF CSB EQUIPMENT LIST

| DESCRIPTION                                                   | EQUIPMENT ID | CAPACITY                        | PHYSICAL SIZE | MATERIAL | POWER           | WBS | COMMENTS           | PROCUREMENT | SC |
|---------------------------------------------------------------|--------------|---------------------------------|---------------|----------|-----------------|-----|--------------------|-------------|----|
| Heating                                                       | AHU-4B       | 85,4000 BTUH                    |               |          | 25 KW           | 260 | Standby            |             | 4  |
| Air Handling Unit                                             | AHU-5        | 2,000 CFM                       |               |          | 3 HP            | 240 |                    |             | 4  |
| 300A, 480/277V, 3 $\phi$ , 4W<br>Automatic Transfer<br>Switch | ATS-1        |                                 |               |          |                 | 240 | SC2 Elec Eqpt Room |             | 2  |
| 300A, 480/277V, 3 $\phi$ , 4W<br>Automatic Transfer<br>Switch | ATS-2        |                                 |               |          |                 | 240 | SC2 Elec Eqpt Room |             | 2  |
| Air Compressor                                                | C-1A         | 110 SCFM, 125 $\Delta$ P        |               | CS       | 25 HP           | 240 |                    |             |    |
| Air Compressor                                                | C-1B         | 110 SCFM, 125 $\Delta$ P        |               | CS       | 25 HP           | 240 |                    |             |    |
| MCO Handling Machine<br>Cask                                  | CK-1         | 1 MCO                           |               | CS       | 2, 1 HP         | 230 | Expense Funded     | Early       |    |
| Flask, Floor Plug                                             | CK-2         | 1 Plug                          |               | CS       | 1 HP            | 230 |                    |             |    |
| Crane, Bridge Transport<br>Cask                               | CN-1         | 40 Ton Main Hoist<br>10 Ton AUX | 40' Span      | CS       | 15, 5, 5, 2, HP | 220 |                    | Early       |    |
| Crane, Jib Cask Lid<br>Handling                               | CN-3         | 10 Ton                          | 6' Boom       | CS       | 2, 1 HP         | 220 |                    |             |    |
| MCO Handling Machine,<br>Crane                                | CN-4         | 25 Ton Hoist                    | 135' Span     | CS       | 2, 5, 5 HP      | 230 |                    | Early       |    |
| Cart, Transfer, Cask<br>(with Rail & Controls)                | CN-5A        | 30 Ton                          |               | CS       | 2 HP            | 220 |                    |             |    |
| Cart, Transfer, Cask<br>(with Rail & Controls)                | CN-5B        | 30 Ton                          |               | CS       | 2 HP            | 220 |                    |             |    |

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SNF CSB EQUIPMENT LIST

| DESCRIPTION                                 | EQUIPMENT ID | CAPACITY        | PHYSICAL SIZE | MATERIAL | POWER         | WBS | COMMENTS | PROCUREMENT | SC |
|---------------------------------------------|--------------|-----------------|---------------|----------|---------------|-----|----------|-------------|----|
| Crane, Under Hung                           | CN-6         | 5 Ton           | Span 38'      | CS       | 1, 1, 1, 1 HP | 220 |          | Early       |    |
| Instrument Air Dryer                        | DY-1         | 150 Psig, 350 F |               | CS       |               | 240 |          |             |    |
| Emergency Exh Fan "A"                       | EF-1A        | 6,000 CFM       |               |          | 15 HP         | 260 |          |             | 2  |
| Emergency Exh Fan "B"                       | EF-1B        | 6,000 CFM       |               |          | 15 HP         | 260 |          |             | 2  |
| Recirc/Exh Fan "A"                          | EF-2A        | 12,000 CFM      |               |          | 25 HP         | 260 |          |             | 3  |
| Recirc/Exh Fan "B"                          | EF-2B        | 12,000 CFM      |               |          | 25 HP         | 260 | Standby  |             | 3  |
| Exhaust Fan "A"                             | EF-3A        | 4,000 CFM       |               |          | 10 HP         | 260 |          |             | 2  |
| Exhaust Fan "B"                             | EF-3B        | 4,000 CFM       |               |          | 10 HP         | 260 | Standby  |             | 2  |
| Exhaust Fan                                 | EF-4         | 2,000 CFM       |               |          | 1 HP          | 240 |          |             | 4  |
| Generator, Diesel with Associated Equipment | EG-1A        | 80 kW           |               |          |               | 280 |          |             |    |
| Generator, Diesel with Associated Equipment | EG-1B        | 80 kW           |               |          |               | 280 |          |             |    |
| Electric Unit Heaters                       | EH-1         | 3,413 BTUH      |               |          | 10 KW         | 220 |          |             | 4  |
| Electric Unit Heaters                       | EH-2         | 3,413 BTUH      |               |          | 10 KW         | 220 |          |             | 4  |
| Electric Unit Heaters                       | EH-3         | 3,413 BTUH      |               |          | 10 KW         | 220 |          |             | 4  |
| Electric Unit Heaters                       | EH-4         | 3,413 BTUH      |               |          | 10 KW         | 220 |          |             | 4  |
| Electric Unit Heaters                       | EH-5         | 34,130 BTUH     |               |          | 10 KW         |     |          |             | 4  |
| Electric Unit Heaters                       | EH-6         | 34,130 BTUH     |               |          | 10 KW         |     |          |             | 4  |

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SNF CSB EQUIPMENT LIST

| DESCRIPTION                           | EQUIPMENT ID | CAPACITY                        | PHYSICAL SIZE | MATERIAL | POWER        | WBS | COMMENTS | PROCUREMENT           | SC |
|---------------------------------------|--------------|---------------------------------|---------------|----------|--------------|-----|----------|-----------------------|----|
| Electric Unit Heaters                 | EH-7         | 34,130 BTUH                     |               |          | 10 KW        |     |          |                       | 4  |
| Electric Unit Heaters                 | EH-8         | 34,130 BTUH                     |               |          | 10 KW        |     |          |                       | 4  |
| Vac Sys HEPA Filters                  | F-3A         | 102 ACFM, 15<br>Psig/FV, 150 .F |               | 304L     |              | 240 |          |                       |    |
| Vac Sys HEPA Filters                  | F-3B         | 102 ACFM, 15<br>Psig/FV, 150 .F |               | 304L     |              | 240 |          |                       |    |
| Gate, Portable Shielding              | HA-1         |                                 |               | CS       | 1 HP         | 230 |          |                       |    |
| Gate, Fixed Shielding                 | HA-2         |                                 |               | CS       | 1 HP         | 230 |          | Early (Embed<br>Only) |    |
| Hatch, Cask Entrance                  | HA-4         |                                 | 60"           | CS       | 2 HP         | 220 |          | Early (Embed<br>Only) |    |
| Lances (one lot)                      | HD-1         |                                 |               |          |              | 220 |          |                       |    |
| Unbolting Device                      | HD-2         |                                 |               |          | 1, 1, .25 HP | 220 |          |                       |    |
| Grapple, Cask Lid                     | HD-3         |                                 |               | SS       | 1 HP         | 220 |          |                       |    |
| Yoke, Transport Cask                  | HD-4         | 30 Ton                          |               | CS       |              | 220 |          |                       |    |
| MCO (empty) Handling<br>Device        | HD-6         |                                 |               |          |              | 220 |          |                       |    |
| Yoke, Floor Gate & Floor<br>Plug Cask | HD-7         | 25 Ton                          |               | CS       |              | 230 |          |                       |    |
| Railcar Moving Device                 | HD-8         |                                 |               | CS       | 2 HP         | 220 |          |                       |    |
| HPS Vac Sys Blowers                   | MB-1A        | 110 ACFM, 9.8 ΔP                |               | CS       | 20 HP        | 240 |          |                       |    |

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SNF CSB EQUIPMENT LIST

| DESCRIPTION                              | EQUIPMENT ID | CAPACITY         | PHYSICAL SIZE | MATERIAL | POWER    | WBS | COMMENTS                 | PROCUREMENT | SC |
|------------------------------------------|--------------|------------------|---------------|----------|----------|-----|--------------------------|-------------|----|
| HPS Vac Sys Blowers                      | MB-1B        | 110 ACFM, 9.8 ΔP |               | CS       | 20 HP    | 240 |                          |             |    |
| 480V, 3 φ, 60 HZ, 300A<br>MCC, Train "A" | MCC-1        |                  |               |          |          | 240 | SC2 Elec Eqpt Room       |             | 2  |
| 480V, 3 φ, 60 HZ, 300A<br>MCC, Train "B" | MCC-2        |                  |               |          |          | 240 | SC2 Elec Eqpt Room       |             | 2  |
| 480V, 3 φ, 60 HZ, 800A<br>MCC, Train "A" | MCC-3        |                  |               |          |          | 240 | Normal Elec Eqpt<br>Room |             | 3  |
| 480V, 3 φ, 60 HZ, 800A<br>MCC, Train "B" | MCC-4        |                  |               |          |          | 240 | Normal Elec Eqpt<br>Room |             | 3  |
| Waste Wash Water Sump<br>Pump            | P-4          | 30 GPM, 10 ΔP    |               | 304L     | .175 MHP | 220 |                          |             |    |
| Process Water Pumps                      | P-7A         | 4 GPM, 22 ΔP     |               | 304L     | .051 MHP | 240 |                          |             |    |
| Process Water Pumps                      | P-7B         | 4 GPM, 22 ΔP     |               | 304L     | .051 MHP | 240 |                          |             |    |
| Pump, Drain Lines                        | P-8A         |                  |               |          | 5 HP     | 270 |                          |             |    |
| Pump, Drain Lines                        | P-8B         |                  |               |          | 5 HP     | 270 |                          |             |    |
| HEPA Filter Plenum "A"                   | PF-1A        | 6,000 CFM        |               |          |          | 260 |                          |             | 2  |
| HEPA Filter Plenum "B"                   | PF-1B        | 6,000 CFM        |               |          |          | 260 |                          |             | 2  |
| HEPA Filter Plenum "A"                   | PF-2A        | 12,000 CFM       |               |          |          | 260 |                          |             | 3  |
| HEPA Filter Plenum "B"                   | PF-2B        | 12,000 CFM       |               |          |          | 260 | Standby                  |             | 3  |
| HEPA Filter Plenum "A"                   | PF-3A        | 4,000 CFM        |               |          |          | 260 |                          |             | 2  |
| HEPA Filter Plenum "B"                   | PF-3B        | 4,000 CFM        |               |          |          | 260 | Standby                  |             | 2  |

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SNF CSB EQUIPMENT LIST

| DESCRIPTION                                                                      | EQUIPMENT ID  | CAPACITY | PHYSICAL SIZE | MATERIAL | POWER | WBS | COMMENTS                      | PROCUREMENT | SC |
|----------------------------------------------------------------------------------|---------------|----------|---------------|----------|-------|-----|-------------------------------|-------------|----|
| Floor Plugs, MCO                                                                 | PL-1 (660 ea) |          |               |          |       | 230 |                               | Early       |    |
| Floor Plugs, Overpack                                                            | PL-2 (17 ea)  |          |               |          |       | 230 |                               | Early       |    |
| 15kVA, 12 CKT,<br>480-208/120V, 3 $\phi$ , 4W,<br>Panel Board, Fully<br>Equipped | PNL BRD-1     |          |               |          |       | 240 | SC2 Elec Eqpt Room            |             | 2  |
| 15kVA, 12 CKT,<br>480-208/120V, 3 $\phi$ , 4W,<br>Panel Board, Fully<br>Equipped | PNL BRD-2     |          |               |          |       | 240 | SC2 Elec Eqpt Room            |             | 2  |
| 15kVA, 12 CKT,<br>480-208/120V, 3 $\phi$ , 4W,<br>Panel Board, Fully<br>Equipped | PNL BRD-3     |          |               |          |       | 240 | Normal Elec Eqpt<br>Room      |             | 3  |
| 15kVA, 12 CKT,<br>480-208/120V, 3 $\phi$ , 4W,<br>Panel Board, Fully<br>Equipped | PNL BRD-4     |          |               |          |       | 240 | Normal Elec Eqpt<br>Room      |             | 3  |
| Pole Mounted Hardware<br>for Service Drop                                        | POLE-         |          |               |          |       |     |                               |             |    |
| Impact Absorbers, MCO,<br>Lower                                                  | RA-1 (375 ea) |          |               |          |       |     | Existing 13.8 kV<br>Pole Line |             | 3  |
| Impact Absorbers, MCO,<br>Upper                                                  | RA-2 (375 ea) |          |               |          |       | 230 | Expense Funded                |             |    |
| Impact Absorbers,<br>Overpack, Lower                                             | RA-3 (10 ea)  |          |               |          |       | 230 | Expense Funded                |             |    |

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SNF CSB EQUIPMENT LIST

| DESCRIPTION                       | EQUIPMENT ID | CAPACITY  | PHYSICAL SIZE  | MATERIAL | POWER  | WBS | COMMENTS | PROCUREMENT        | SC |
|-----------------------------------|--------------|-----------|----------------|----------|--------|-----|----------|--------------------|----|
| Power Roof Ventilator             | RV-1         | 4,000 CFM |                |          | 2 HP   | 220 |          |                    | 4  |
| Power Roof Ventilator             | RV-2         | 4,000 CFM |                |          | 2 HP   | 220 |          |                    | 4  |
| Power Roof Ventilator             | RV-3         | 4,000 CFM |                |          | 2 HP   | 220 |          |                    | 4  |
| Power Roof Ventilator             | RV-4         | 4,000 CFM |                |          | 2 HP   | 220 |          |                    | 4  |
| Cask, Internal Sampling Equipment | SA-1         |           |                |          | .25 HP | 220 |          |                    |    |
| Shield Door                       | SD-1A        |           | 5" x 12' x 20' | CS       | 1 HP   | 220 |          |                    |    |
| Shield Door                       | SD-1B        |           | 5" x 12' x 20' | CS       | 1 HP   | 220 |          |                    |    |
| Shield Door                       | SD-2A        |           | 4" x 12' x 20' | CS       | 1 HP   | 220 |          |                    |    |
| Shield Door                       | SD-2B        |           | 4" x 12' x 20' | CS       | 1 HP   | 220 |          |                    |    |
| Shield Door                       | SD-3         |           | 4" x 6' x 20'  | CS       | 1 HP   | 220 |          | Early (Embed Only) |    |
| Shield Door, Personnel            | SD-4A        |           | 5" x 3' x 7'   | CS       |        | 220 |          |                    |    |
| Shield Door, Personnel            | SD-4B        |           | 5" x 3' x 7'   | CS       |        | 220 |          |                    |    |
| Shield Door, Personnel (Double)   | SD-5A        |           | 5" x 6' x 7'   | CS       |        | 240 |          |                    |    |
| Shield Door, Personnel (Double)   | SD-5B        |           | 5" x 6' x 7'   | CS       |        | 240 |          |                    |    |
| Shield Door, Personnel            | SD-6A        |           | 4" x 3' x 7'   | CS       |        | 220 |          |                    |    |
| Shield Door, Personnel            | SD-6B        |           | 4" x 3' x 7'   | CS       |        | 220 |          |                    |    |

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SNF CSB EQUIPMENT LIST

| DESCRIPTION                              | EQUIPMENT ID | CAPACITY   | PHYSICAL SIZE  | MATERIAL         | POWER   | WBS | COMMENTS              | PROCUREMENT        | SC |
|------------------------------------------|--------------|------------|----------------|------------------|---------|-----|-----------------------|--------------------|----|
| Shield Door, Personnel                   | SD-6C        |            | 4" x 3' x 7'   | CS               |         | 220 |                       |                    |    |
| Shield Door, Personnel                   | SD-7         |            | 4" x 6' x 7'   | CS               |         | 220 |                       |                    |    |
| Shield Door Tunnel                       | SD-8         |            | 4" x 3' x 7'   | CS               |         | 220 |                       | Early (Embed Only) |    |
| Shield Door Tunnel                       | SD-9         |            | 8" x 3' x 7'   | CS               |         | 220 |                       | Early (Embed Only) |    |
| Supply Fan "A"                           | SF-1A        | 20,000 CFM |                |                  | 10 HP   |     |                       |                    | 2  |
| Supply Fan "B"                           | SF-2B        | 20,000 CFM |                |                  | 10 HP   |     |                       |                    | 2  |
| Shop Equipment (1 lot)                   | SH-1         |            |                |                  | 5 HP    | 240 |                       |                    |    |
| Nitrogen Cylinder Rack                   | SR-1         |            |                |                  |         |     |                       |                    |    |
| Storage Rack Clean MCO/MCO Overpack/Cask | SR-2         | 28/1/2     |                | 304L             |         | 220 |                       |                    |    |
| MCO Service Station                      | SS-1         |            |                |                  | 1, 1 HP | 220 |                       |                    |    |
| Waste Wash Water Sump                    | SU-1         |            | 8' x 8' x 6' D | Ep Lind Concrete |         | 220 |                       |                    |    |
| 480V, 3 $\phi$ , 60 HZ, 1600 A SWGR      | SWGR-1       |            |                |                  |         | 240 | Normal Elec Eqpt Room |                    | 3  |
| Window, Shield                           | SZ-1A        |            |                |                  |         | 220 |                       | Early (Embed Only) |    |
| Window, Shield                           | SZ-1B        |            |                |                  |         | 220 |                       | Early (Embed Only) |    |
| Window, Shield                           | SZ-1C        |            |                |                  |         | 220 |                       | Early (Embed Only) |    |
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SNF CSB EQUIPMENT LIST

| DESCRIPTION                                                                | EQUIPMENT ID | CAPACITY         | PHYSICAL SIZE | MATERIAL  | POWER            | WBS | COMMENTS           | PROCUREMENT | SC |
|----------------------------------------------------------------------------|--------------|------------------|---------------|-----------|------------------|-----|--------------------|-------------|----|
| Window, Shield                                                             | SZ-1D        |                  |               |           |                  | 220 |                    |             |    |
| Window, Shield                                                             | SZ-1E        |                  |               |           |                  | 220 |                    |             |    |
| Window, Shield                                                             | SZ-1F        |                  |               |           |                  | 220 |                    |             |    |
| Window, Shield                                                             | SZ-1G        |                  |               |           |                  | 220 |                    |             |    |
| CCTV                                                                       | TV-1A        |                  |               |           | .25, .25, .25 HP | 220 |                    |             |    |
| CCTV                                                                       | TV-1B        |                  |               |           | .25, .25, .25 HP | 220 |                    |             |    |
| CCTV                                                                       | TV-1C        |                  |               |           | .25, .25, .25 HP | 220 |                    |             |    |
| 3 kVA, 120V, 1 $\phi$ , 3W,<br>W/Batteries 15 Min UPS                      | UPS-1        |                  |               |           |                  | 240 | SC2 Elec Eqpt Room |             | 2  |
| 3 kVA, 120V, 1 $\phi$ , 3W,<br>W/Batteries 15 Min UPS                      | UPS-2        |                  |               |           |                  | 240 | SC2 Elec Eqpt Room |             | 2  |
| 10 kVA, 208/120V, 1 $\phi$ ,<br>3W, W/Batteries 15 Min<br>UPS              | UPS-3        |                  |               |           |                  | 240 | Control Room       |             | 3  |
| Instrument Air Receiver                                                    | V-1          | 150 Psig, 150 'F | 8' x 8'       | CS        |                  | 240 |                    |             |    |
| Waste Wash Water Hold<br>Tank                                              | V-6          | 15 Psig, 100 'F  | 6' x 10'      | Ep Lnd CS |                  | 240 |                    |             |    |
| Process Water Storage<br>Tank                                              | V-8          | 15 Psig, 150 'F  | 7.5' x 16'    | 304L      |                  | 240 |                    |             |    |
| Wash Rack                                                                  | WR-1         |                  |               |           |                  | 220 |                    |             |    |
| 750 kVA, 13.8 - 0.48 KV,<br>3 $\phi$ , 4W, Pad Mounted, Oil<br>Filled XFMR | XFMR-1       |                  |               |           |                  |     | Outdoor            |             | 3  |

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WHC P.O. TVW-SVV-370252

Fluor Daniel, Inc.  
Government Services  
Contract 04436307

**ATTACHMENT B**  
**SNF CSB**  
**LONG-LEAD PROCUREMENT LIST**

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| DESCRIPTION                     | EQUIPMENT ID  | CAPACITY                        | PHYSICAL SIZE | MATERIAL | POWER           | WBS | COMMENTS       | PROCUREMENT           | SC |
|---------------------------------|---------------|---------------------------------|---------------|----------|-----------------|-----|----------------|-----------------------|----|
| Storage Tubes, MCO              | (440 ea)      |                                 |               |          |                 | 230 |                | Early                 |    |
| Storage Tubes Overpack          | (12 ea)       |                                 |               |          |                 | 230 |                | Early                 |    |
| Floor Plug Embed,<br>Standard   | (660 ea)      |                                 |               |          |                 | 230 |                | Early                 |    |
| Floor Plug Embed,<br>Overpack   | (17 ea)       |                                 |               |          |                 | 230 |                | Early                 |    |
| MCO Handling Machine<br>Cask    | CK-1          | 1 MCO                           |               | CS       | 2, 1 HP         | 230 | Expense Funded | Early                 |    |
| Crane, Bridge Transport<br>Cask | CN-1          | 40 Ton Main Hoist<br>10 Ton Aux | 40' Span      | CS       | 15, 5, 5, 2, HP | 220 |                | Early                 |    |
| MCO Handling Machine,<br>Crane  | CN-4          | 25 Ton Hoist                    | 135' Span     | CS       | 2, 5, 5 HP      | 230 |                | Early                 |    |
| Crane, Under Hung               | CN-6          | 5 Ton                           | Span 38'      | CS       | 1, 1, 1, 1 HP   | 220 |                | Early                 |    |
| Floor Plugs, MCO                | PL-1 (660 ea) |                                 |               |          |                 | 230 |                | Early                 |    |
| Floor Plugs, Overpack           | PL-2 (17 ea)  |                                 |               |          |                 | 230 |                | Early                 |    |
| Gate, Fixed Shielding           | HA-2          |                                 |               | CS       | 1 HP            | 230 |                | Early (Embed<br>Only) |    |
| Hatch, Cask Entrance            | HA-4          |                                 | 60"           | CS       | 2 HP            | 220 |                | Early (Embed<br>Only) |    |
| Shield Door                     | SD-3          |                                 | 4" X 6' X 20' | CS       | 1 HP            | 220 |                | Early (Embed<br>Only) |    |

Note: Basis -1) Installed early in cost reduction  
2) Lengthy design and fabrication cycle

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SNF CSB  
LONG-LEAD PROCUREMENT LIST

| DESCRIPTION        | EQUIPMENT ID | CAPACITY | PHYSICAL SIZE | MATERIAL | POWER | WBS | COMMENTS | PROCUREMENT        | SC |
|--------------------|--------------|----------|---------------|----------|-------|-----|----------|--------------------|----|
| Shield Door Tunnel | SD-8         |          | 4" x 3' x 7'  | CS       |       | 220 |          | Early (Embed Only) |    |
| Shield Door Tunnel | SD-9         |          | 8" x 3' x 7'  | CS       |       | 220 |          | Early (Embed Only) |    |
| Window, Shield     | SZ-1A        |          |               |          |       | 220 |          | Early (Embed Only) |    |
| Window, Shield     | SZ-1B        |          |               |          |       | 220 |          | Early (Embed Only) |    |
| Window, Shield     | SZ-1C        |          |               |          |       | 220 |          | Early (Embed Only) |    |

Note: Basis -1) Installed early in cost reduction  
2) Lengthy design and fabrication cycle

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### APPENDIX III

#### STRUCTURAL ENGINEERING CALCULATIONS

- A. Concrete Design Life Study
- B. Analysis of Cask Drop on Operating Floor

## APPENDIX III. A

### CONCRETE DESIGN LIFE STUDY

- 1.0 INTRODUCTION
- 2.0 DESIGN MATERIALS
- 3.0 PROCESSES RESPONSIBLE FOR CONCRETE DEGRADATION
- 4.0 CONCLUSIONS
- 5.0 OPEN STRUCTURAL ISSUES

## 1.0 INTRODUCTION

The Draft Performance Specification calls for a 200 year design life for SNF CSB structures. This Appendix examines in detail the factors affecting concrete design life. Additionally, structural open issues requiring direction and resolution by WHC are identified.

## 2.0 DESIGN MATERIALS

### 2.1 CONCRETE MATERIALS

The concrete mix designs specified for the CSB are MC5P, MC6P, MC7P, and MC8P (HWVP Spec. B-595-A-A900) with the following material properties :

|                      |                                                                                                                                                                    |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cement               | Type II (moderate sulfate resistance).                                                                                                                             |
| Water                | Clean & potable, chloride ( $Cl^-$ ) ions not to exceed 250 ppm.                                                                                                   |
| Coarse Aggregate     | Igneous rock such as basalt, dolerite and garbo, 1" max. Petrographic examination required per ASTM C295.                                                          |
| Fine Aggregate       | Fragments from coarse aggregate or metamorphic such as metasandstone or metaquartzite.                                                                             |
| Fly-Ash              | ASTM C618, Type F, 25 to 30 percent of cement weight.                                                                                                              |
| Air-Entraining       | ASTM C260, chloride free, for concrete exposed to environment only. For 1" aggregate and moderate exposure 4.5% air content is required (ACI 318-89, Table 4.1.1). |
| Super plasticizer    | High range water reducing agents conforming to ASTM C494 , Type F, chloride free.                                                                                  |
| Slump                | 2 to 4 inch initial, 7 to 9 inch final after addition of super plasticizer.                                                                                        |
| Water-cement ratio   | Maximum 0.45 by weight.                                                                                                                                            |
| Compressive Strength | MC5P & MC6P=5000 psi at 90 days<br>MC7P & MC8P=6000 psi at 90 days                                                                                                 |



Chloride ion limit                      Maximum water soluble chloride ion concentration in hardened concrete not to exceed 0.15 percent by weight of cement as tested by AASHTO T260.

## 2.2 SOIL PROPERTIES

The HWVP Geotechnical Report has identified in Plate B-3 the following range of chemicals and moisture is the site soil:

|                    |                        |                       |
|--------------------|------------------------|-----------------------|
| Sulfides           | negative               |                       |
| Sulfates           | 8.2 to 280 ppm         | average value 144 ppm |
| Chlorides          | 1.4 to 66.5 ppm        | average value 34 ppm  |
| pH                 | 8.3 to 9.2             |                       |
| Moisture           | 1.4 to 3.4 percent     |                       |
| Ground water table | 310 feet below surface |                       |
| Soil Type          | SM/GM                  |                       |
| Frost depth        | 30 inches              |                       |

## 3.0 PROCESSES RESPONSIBLE FOR CONCRETE DEGRADITION

### 3.1 ENVIRONMENTAL-RELATED CAUSES OF CONCRETE DEGRADATION

#### 3.1.1 Sulfate Exposures

For sulfates in the soils in the range of 8 to 280 ppm, ACI 318-89 classifies as negligible to moderate exposure, and recommends use of type II cement (containing no more than 8% tricalcium aluminate ( $C_3A$ ) by weight) and maximum water-cement ratio (WCR), by weight, of 0.50. For the Vault concrete mixes are specified to use type II cement, WCR of 0.45. Additionally fly ash conforming to ASTM C 618, Class F, has been specified and has been known to improve the sulfate resistance of concrete per ACI 318.

From empirical model curves given in Figures 8 and 9 of NUREG/CR-5542 the following degradation loss of concrete surfaces exposed to 280 ppm  $SO_4$  in soils is estimated for 200 years:

| <u><math>SO_4</math>--</u> | <u>Mg++</u> | <u>Cement Type</u> | <u>Loss Degradation, cm</u> |
|----------------------------|-------------|--------------------|-----------------------------|
| 40 ppm                     | 20 ppm      | II                 | 1                           |
| 1430 ppm                   | 372 ppm     | II                 | 25                          |
| 280 ppm                    | n/a         | II                 | 6 (by interpolation)        |
| 40 ppm                     | 20 ppm      | V                  | 0.7                         |
| 1430 ppm                   | 372 ppm     | V                  | 15                          |
| 280 ppm                    | n/a         | V                  | 3.2 (by interpolation)      |

From mechanistic model curves given in Figure 10 of NUREG/CR-5542 the rate of sulfate attack is determined as follows:

| <u>SO<sub>4</sub>--</u> | <u>Mg++</u> | <u>Cement Type</u> | <u>Sulfate attack rate, cm/yr</u>           |
|-------------------------|-------------|--------------------|---------------------------------------------|
| 100 ppm                 |             | V                  | 0.03                                        |
| 500 ppm                 |             | V                  | 0.2                                         |
| 280 ppm                 |             | V                  | 0.106 ( by interpolation)                   |
|                         |             |                    | Loss over 200 years = 200x0.106= 21.3<br>cm |
|                         |             |                    | Loss over 50 years = 50x 0.106 = 5.3<br>cm  |

The intrinsic diffusion coefficient required in NUREG/CR-5542 Figure 10 was calculated to be 0.7E-7 from NUREG/CR-5542 Figure 3 for WCR=0.45

Thus we obtain radically different values of 3.2 and 21.3 cm loss over 200 years when concrete containing sulfate resistant cement is exposed to 280 ppm SO<sub>4</sub>. The design concrete cover provided is 7.6 cm for the foundation mat and 5 cm for the walls. Therefore, should the vault concrete be exposed to the maximum SO<sub>4</sub> value of 280 ppm determined in the site soils, the design service life will not be achieved even with using Type V sulfate resisting cement. Using the average value of SO<sub>4</sub> (50% of max.), the concrete loss could be between 1.6 to 10.7 cm using the above prediction models. It is possible to achieve vault concrete service life of approximately 100 years with the current design and concrete quality. Note that the foundation mat and a small portion of the walls are constructed.

### 3.1.2 Reinforcement corrosion/ Chloride exposure

Exposure of reinforcement to chloride ion (Cl<sup>-</sup>) causes corrosion which results in cracking of the concrete due to significant increase in the rebar's molar volume. The start of reinforcement corrosion is thought to be associated with critical or threshold chloride level of 0.02 mass percent of the cement paste or about 700 ppm in the pore solution (NUREG/CR-5542). Also, in the absence of elevated levels of chloride, reinforcement corrosion may begin when the alkalinity of the concrete drops below 9. From the HWVP Geotechnical Report the chlorides content in the site soil varies from 1.4 to 66.5 ppm (34 ppm average), and the maximum water soluble chloride ion in concrete has been limited to 0.15 percent by weight of cement.

Table 2-2 represents the time of corrosion based on chloride content for various concrete thickness.

From NUREG/CR-5542, the time for initiation (onset) of corrosion can be calculated by

$$t_c = \frac{129 X_c^{1.22}}{(WCR) [Cl]^{0.42}}$$

where

$t_c$  = time to onset of corrosion in years

$X_c$  = thickness of concrete cover over the rebar in inches

WCR = water-cement ratio by weight, 0.45

Cl = chloride ion in ppm, 66.5 max. or 34 average in site soil

Table 2-2

| $X_c$ , cm          | 1  | 2  | 3  | 4   | 5   | 6   | 7   | 8   |
|---------------------|----|----|----|-----|-----|-----|-----|-----|
| $t_c$ (66.5 ppm Cl) | 16 | 37 | 60 | 85  | 112 | 141 | 170 | 200 |
| $t_c$ (34 ppm Cl)   | 21 | 49 | 80 | 113 | 149 | 186 | 224 | 264 |

Thus rebar corrosion could be initiated as early as 112 years for 5 cm (2") concrete cover on walls and 66.5 ppm  $Cl^-$  ion. The time would be further reduced if coupled with sulfate attack which reduces the concrete cover as indicated earlier. Assuming 50% loss of concrete cover in 50 years, then for 2.5 cm cover the corrosion onset would be at about 48 years after the 50 years or 98 years. To obtain 200 years service life an additional 2 inches concrete cover is required.

### 3.1.3 Freezing and Thawing Exposures

Concrete structures that are not buried below the local freezing depth will be exposed to freeze/thaw cycles. The non-accessible portion of the vault (foundation mat and below grade walls) and the enclosed operating deck floor are not subject to freezing and thawing. Air-entrained (4.5%) concrete and low WCR of 0.45 has been specified for concrete that is exposed to the weather to increase its frost-resistance. Any damage to the exposed concrete is repairable. Thus this condition does not influence the service life of the structures.

### 3.1.4 Ground Water Exposure

The SNF CSB is not subject to this condition since the ground water table is 310 feet below the surface, and as such has no impact on the service life.

### 3.1.5 Carbonation

Carbon dioxide reacts with cement components to form carbonates, a process referred to as carbonation which is accompanied by shrinkage and decrease in the pH of concrete. Carbonation can be either beneficial or harmful depending on the time, rate, and extent to which they occur. The rate of carbonation depends upon the moisture content of the concrete and the relative humidity of the ambient medium. Below 25 percent relative humidity, the degree of carbonation that takes place is considered insignificant (ACI 201.2R) and high rate of carbonation occurs at about 50 to 75 percent range. From NUREG/CR-5542 Figure 19, the depth of carbonation attack in the midwest/arid regions is estimated at 0.12 cm in 200 years and can be considered negligible.

### 3.1.6 Oxidation and Biodegradation of Coatings and Sealants

No coatings or sealants are required or specified for the vaults's interior surfaces. Epoxy coatings may be specified in the Cask/MCO unloading area, and any damage occurring will be repaired as part of facility operations and maintenance.

## 3.2 MATERIAL RELATED CAUSES OF CONCRETE DEGRADATION

### 3.2.1 Alkali-Aggregate Reaction

Certain aggregates or their constituents have tendency to react with the alkalis in cement causing excessive expansion and premature deterioration of concrete. The concrete specification has stipulated petrographic and potential reactivity testing of the aggregates and therefore should be able to eliminate this cause.

### 3.2.2 Leaching

Cement components will be leached from concrete in environments that are in contact with water and have significant water percolation rate. The SNF CSB is not subject to such an environment and therefore this process has no impact on its service life.

### 3.2.3 Construction Deficiencies

Implementation of quality control procedures during all phases of material selection, inspection and testing, concrete mix design, production, delivery, placing, and curing are essential in minimizing material and construction deficiencies. All defective concrete is required to be removed and repaired by approved procedures. A requirement will be included in the specification for detailed inspection of constructed vault for identification of visible cracks and surface defects. This inspection should be carried out before backfill of the exterior below grade walls and

prior to installation of storage tubes in the vault. It is recommended that the Engineer of Record be part of the inspection team. Repairs shall be made per procedures approved by the Engineer of Record.

#### **3.2.4 Contaminating Substances in Aggregates**

Aggregate is commonly contaminated by silt, clay, mica, coal, humus, wood fragments, other organic matter, chemical salts, and surface coatings and encrustation. Such substances in concrete act in variety of ways to cause unsoundness and decreased strength and durability. The concrete specification for the SNF CSB includes aggregate testing requirements to prevent inclusion of such contaminants over a certain permissible percentages. It is recommended that petrographic examination and chemical analysis of the aggregates, water and cement be carried out and approved by the Engineer of Record early to forestall any construction delays due to rejection of unsuitable materials.

#### **3.2.5 Reinforcing/Prestressing Steel Relaxation**

No prestressing steel is used in the CSB and hence this is not an issue.

### **3.3 SERVICE RELATED CAUSES OF CONCRETE DEGRADATION**

#### **3.3.1 Cracking**

Cracking can result from a number of phenomena including drying shrinkage, temperature change stress, reinforcement corrosion with resulting expansion, carbonation, and physical loadings. Measures such as: low heat of hydration cement, fly-ash, low water-cement ratio, cold and hot temperature concreting requirements, and curing requirements have been specified to minimize volume change from temperature rise during setting, and drying shrinkage. The effects of reinforcement corrosion and carbonation have been addressed earlier.

Cracking as a result of volume change from seasonal temperature variations and the heat generated by the SNF stored material has been mitigated by designing the structure for the imposed stresses and providing uniform distribution of the reinforcing steel in accordance with ACI 318-89 Section 10.6 for crack control.

#### **3.3.2 Abrasion/Wear**

The SNF CSB structures are not subject to operations such as vehicular traffic that can cause abrasion of the concrete surfaces. Wear due to wind or waterborne particles is considered minimal. The operating deck floor surface will have a sealer/hardener coating that would prevent dusting of concrete. Other factors such

as: abrasion testing of coarse aggregates, low WCR, avoiding segregation and bleeding, steel trowel finishing, and proper curing, have been specified to provide sound concrete.

### 3.3.3 Settlement

In accordance with HWVP Geotechnical Investigation Report, any small amount of settlement that may occur would be elastic in nature, and will occur essentially simultaneous with the application of loads. No long term settlement is anticipated. Therefore, this condition has negligible impact on the design/service life of the facility.

### 3.3.4 Irradiation

Concrete with low permeability and porosity acts an effective barrier for migration of most radionuclides as stated in the NUREG/CR-5542. The quality of concrete specified for the project meets this requirement.

### 3.3.5 Thermal Exposure

The concrete vault is exposed to cyclic temperatures in the range of 50 to 150° F resulting from convective cooling of the hot MCOs in the storage tubes. Concrete properties, modified for thermal degradation, have been used in the design of SNF CSB. The HWVP CSB design was based on temperature exposure as high as 200° F and design life of 40 years. There will be no additional degradation of concrete over 200 years if the concrete will now be exposed to less than 150° F.

### 3.3.6 Acid Exposure

The storage vault is not exposed to any acids or harmful chemicals and no protective coatings are required. Concrete in the Cask/MCO unloading area may be subject to decontamination chemicals and will be protected with an appropriate coating system. Such coatings will require maintenance and repair to achieve a 200 year service life.

## 4.0 CONCLUSIONS

A preliminary evaluation of the concrete exposed to various environmental, material, and service-related conditions has indicated that the sulfates and chlorides in the site soils are the predominant factors that are influencing the design/service life of the concrete structures below grade. As stated in NUREG/CR-5542, it is apparent that available models for predicting service life of concrete are limited in terms of scope and validity. Models for predicting concrete longevity for combined or coupled effect of all processes working simultaneously are not available. Given the current state of model development, the classical conservative

analysis mode of calculations may be more appropriate. It should be recognized that low moisture content in the soils, arid climate, and deep water table will slow the rate of chlorides and sulfates attack.

Cracking of the concrete facilitates degradation by other processes and it is very difficult to predict where and when cracks will appear. Even a small crack can change the transport properties of concrete by orders of magnitude. Even if all the cracks have been sealed and no new crack formation is expected, it is difficult to clearly demonstrate in a performance assessment that no new cracks will form. Nuclear power plants were typically designed for a service life of 40 years, and studies on concrete aging relative to their life extension (NUREG/ CR-4652) have shown to increase the service life up to a maximum of 25 years.

Options that could be considered for increasing the design life are: 1) Washing the site soils used for backfill to remove harmful chemicals; 2) providing an additional 1 to 2 inch layer of sacrificial concrete on surfaces in contact with soils; 3) use Type V sulfate-resistant cement; 4) provide design margins; and 5) provide sulfate and chloride resistant coating system. All these options will add to the facility cost. In our opinion with the current design and maintaining quality in construction, it is possible to achieve design life of 75 to 100 years without significant increase in the facility cost. An expert in concrete chemistry and technology will need to be consulted, preferably during Advanced Conceptual Design, to develop recommendations to improve concrete durability. Samples of various concrete mix designs should be subjected to accelerated laboratory tests to determine degradation rate when exposed to these chemicals.

## 5.0 OPEN STRUCTURAL ISSUES

- 5.1 The DBE PGA and response spectrum for NRC requirements need to be developed soon to mitigate impact on the design and construction schedules.
- 5.2 Correlation between Hanford Site Safety Classes and DOE-STD-1020-94 Performance Categories must be defined prior to start of detailed design.
- 5.3 Preliminary evaluation indicates that the 200 year design life for safety class structures is not achievable with the current design, materials of construction and site soils chemistry. Additional testing of site soils, concrete aggregates, and concrete mix design samples for chemical attack is recommended during the Advanced Conceptual Design so that appropriate measures can be implemented to increase concrete durability. Alternately, this requirement should be deleted or modified.

- 5.4 The project schedule has allotted 2 months (Nov/Dec 95) for detailed design and drawing preparation for the vault. To meet the December 26, 1995 drawing release date the facility configuration and design criteria must be approved and technical issues resolved by August 15, 1995. Also it is recommended that the detailed design for the vault convective cooling analysis, structural analysis for seismic and thermal loads, shielding analysis, and safety analysis commence during Advanced Conceptual Design.



APPENDIX III B.

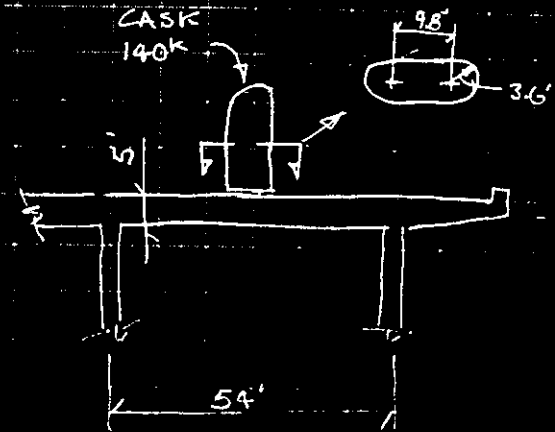
STRUCTURAL CALCULATIONS

Client: WHC  
Project: Spent Nuclear Fuel Canister Storage Building,  
Conceptual Design  
Contract Number: 04436307  
Calculation Number: DS-CD-6  
Title: Analysis of Cask Drop on Operating Floor  
Engr: R. Gruber  
Date: 07/13/95

DS-CD-6

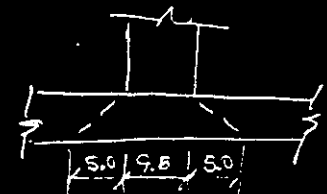
- CASK DROP ANALYSIS -  
- OVERALL RESPONSE -  
ASSUME ELASTIC RESPONSE ( $e=1$ )

REFER TO: HWVP PDG,  
SECTION 10B.4.3



MASS OF MISSILE -  
 $m = 140/32.2 = 4.35 \frac{k \cdot sec^2}{ft}$

MASS OF TARGET -  
EFFECTIVE BEAM WIDTH  $b = 9.8 + 2 \times 5.0 = 19.8'$   
 $m = 5 \times 19.8 \times 0.15 / 32.2 = 0.46 (k \cdot sec^2 / ft) / ft$



EFFECTIVE STIFFNESS OF TARGET -  
 $E = 57000 \sqrt{4000} = 3,605,000 \text{ #/in}^2 = 519,120 \text{ k/ft}^2$   
 $I = 0.75 \times 0.5 \times 19.8 \times 5^3 / 12 = 77.3 \text{ ft}^4$   
CRACKED SECTION TO ACCOUNT FOR PLUG HOLES

MAXIMUM MOMENT (@  $\alpha = 0.2426$ ,  $\mu = 2$ , FIXED-FIXED)

$$M = \frac{3.73}{54 \text{ ft}} \sqrt{\frac{519,120 \text{ k/ft}^2 \times 77.3 \text{ ft}^4}{0.46 \frac{k \cdot sec^2}{ft}}} \cdot \frac{V_0 \text{ ft/sec} \times 4.35 \frac{k \cdot sec^2}{ft} (1+1)}{\sqrt{2 \times 2 - 1}} = 324 V_0 \text{ k-ft}$$

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2



DATE 7-19-95

CONT. NO.

BY RSG

CHK'D

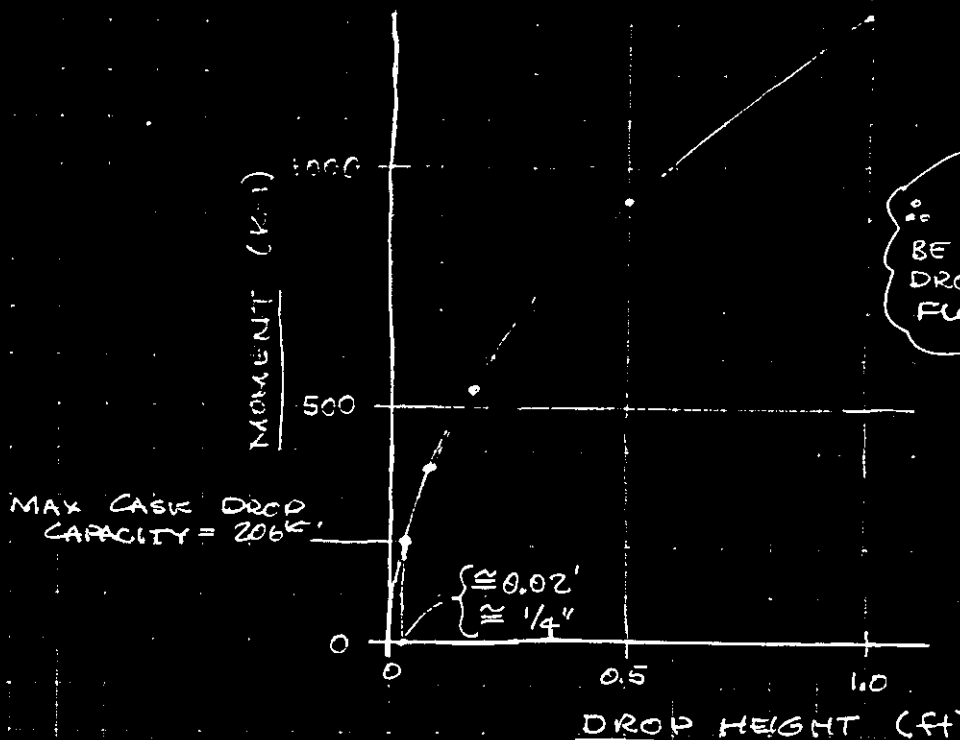
SHEET NO. 2

DS-CD-6

# - CASK DROP ANALYSIS -

$$V_o = \sqrt{2gh}$$

| h          | $V_o$       | $M$       | $w/ft$  |
|------------|-------------|-----------|---------|
| 1" (0.08') | 2.27 ft/sec | 7,356 k-l | 371 k-l |
| 2" (0.17') | 3.31        | 10,723    | 542     |
| 0.5'       | 5.67        | 18,391    | 928     |
| 1.0'       | 8.02        | 26,009    | 1314    |



THE GOVERNING COMBINATION FOR CASK DROP IS DEAD + LIVE + THERMAL + CASK DROP. CASK DROP IS A DESIGN BASIS ACCIDENT WITH LOAD FACTOR = 1.0. REFER TO CALCULATION DS-E350-S-0007, SHEETS 280 THRU 286.

$$\text{MAX NEG CAPACITY} = \phi M_w = 677 \text{ k-l}$$

$$\text{CASK DROP CAPACITY} = \phi M - D - L - T = 677 - 180 - 49 - 242 = 206 \text{ k-l}$$

$$\text{MAX POSITIVE CAPACITY} = 787$$

$$\text{CASK DROP CAPACITY} = 787 - 153 - 43 - 194 = 397 \text{ k-l}$$

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## APPENDIX IV

### HVAC Engineering Data

- A. HVAC Basis for Design
- B. Thermal Analysis

APPENDIX IV. A

HVAC BASIS FOR DESIGN  
FOR  
SPENT NUCLEAR FUEL  
CANISTER STORAGE BUILDING

## Table of Contents

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## 1.0 INTRODUCTION

This document provides the basis for the HVAC system design for the Spent Nuclear Fuel Canister Storage Building (SNF CSB), located within the 200 East Area at the DOE Hanford Site, Richland, Washington.

## 2.0 SCOPE

This document establishes the performance requirements and basic design criteria for HVAC systems serving the SNF CSB. The SNF CSB is a major element of the U.S. Department of Energy (DOE) Spent Nuclear Fuel Project at the Hanford Site. The SNF CSB is needed to expedite the removal of SNF from existing K-Basin temporary storage facilities and to interim-store the SNF until its final disposition.

These requirements and design criteria provide the basis for the development of the conceptual design of the HVAC systems that adapt the designs prepared for the Hanford HWVP Canister Storage Building to accomplish the mission of the SNF CSB.

## 3.0 CODES AND STANDARDS

### 3.1 Technical Requirements Baseline

This design criteria is based on the following:

1. WHC-SD-SNF-FRD-014 Performance Specification for the Spent Nuclear Fuel Canister Storage Building, Rev. A, Draft dated May 17, 1995.
2. DOE-RL-HPS-SDC 5.1 Hanford Plant Standard, Standard Design Criteria for Heating, Ventilating, and Air Conditioning, Rev. 6.
3. DOE-RL-HPS-SDC 4.1 Hanford Plant Standard, Standard Design Criteria Design Loads for Facilities, Rev.12.
4. DOE-RL-HPS-157-M Standard Specification for Fire and Moisture Resistant Nuclear Grade HEPA Filters.

### 3.2 Governing Regulations

The following codes and standards will govern the HVAC design of this project. The latest edition in effect as of June, 1995, will

be used unless specific editions and/or revisions are indicated as applicable:

1. Federal and State Laws
  - a. DOE Order 6430.1A, "General Design Criteria" (dated April 6, 1989).
  - b. DOE/EV/1830-T5, "Guide to Reduction Radiation Exposure to ALARA".
  - c. DOE Order 5820.2A, "Radioactive Waste Management"
2. ACGIH Industrial Ventilation Manual.
3. Air Movement and Control Association (AMCA).
  - a. Publication 99, Standards handbook.
  - b. Publication 210, Fans and Systems.
4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
  - a. ASHRAE 52 Method of Testing Air Cleaning Devices used in General Ventilation for Removal of Particulate Material.
  - b. ASHRAE 62 Ventilation for Acceptable Indoor Air Quality.
5. American National Standards Institute (ANSI).
  - a. ANSI/ASME N509 Nuclear Power Plant Air Cleaning Units and Components.
  - b. ANSI/ASME N510 Testing of Nuclear Air Cleaning Systems.
6. International Conference of Building Officials.
  - a. Uniform Building Code (UBC).
  - b. Uniform Mechanical Code (UMC).
7. National Fire Protection Association.
  - a. NFPA 90A Air Conditioning and Ventilation Systems.
  - b. NFPA 91 Blower and Exhaust Systems.
8. Nuclear Air Cleaning Handbook - ERDA 76-21.
9. Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
  - a. HVAC Duct Construction Standard.



#### 4.0 GENERAL CONSIDERATIONS

##### 4.1 Safety Classification

HVAC systems required to prevent on-site contamination must be Safety Class 2.

##### 4.2 Design Basis Power Failure

Safety Class 2 HVAC systems will be supplied with emergency stand-by power to ensure system reliability in the event of an accident.

##### 4.3 Contamination Confinement

The HVAC design shall confine contamination to the vicinity of the source and minimize contamination spread. The ventilation system will provide contamination confinement and function with the building enclosures to ensure contamination control. Confinement will be achieved by ventilation control (differential pressure), by directing air from uncontaminated areas towards areas of higher contamination, by use of high efficiency particulate air (HEPA) or equivalent filtration or equivalent back flow isolation, and by use of controlled personnel traffic patterns.

Definition of ventilation zone minimum zone pressures with respect to the atmosphere are specified in Table 4.1. Airlocks are provided as required to separate zones, to ensure ventilation balance and contamination control, and to maintain pressure differentials. Within a zone, air flow is from less contaminated to more contaminated areas.

Air recirculation from a zone of higher contamination back to a zone of lesser contamination is prohibited. If air is cascaded from one zone to another of higher contamination potential, backflow protection between zones is to be provided. Backflow protection between zones shall be HEPA filters or an equivalent backflow isolation device.

**TABLE 4.1**  
**HVAC - VENTILATION ZONES**

| ZONE                          | MINIMUM<br>DP<br>(in. WG) | DESCRIPTION OF TYPICAL AREAS                                                                                                                                           |
|-------------------------------|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I - Process Zone              | - 1.0                     | High and potentially high contamination areas.                                                                                                                         |
| II - Control Zone             | - 0.5                     | Areas providing access or penetrations to Zone I. Not normally contaminated areas with moderate contamination potential. May be normally or frequently occupied areas. |
| III - Operating Zone          | - 0.25                    | Not normally contaminated areas with low contamination potential. Normally or frequently occupied areas.                                                               |
| IIIA - Operating Zone         | - 0.1                     | Less contamination potential than Zone III. Minimum DP may not be maintained with outer doors open.                                                                    |
| IV - Uncontrolled Access Zone | + 0.125                   | Clean areas. Areas where contamination is unacceptable.                                                                                                                |
| Neutral Zone                  | N/A                       | Areas not requiring confinement ventilation.                                                                                                                           |

DP = Differential pressure with respect to atmospheric pressure.

N/A = Not Applicable.

WG = Water Gage.

#### 4.4 Filtration Requirements

HEPA filtration or equivalent filtration systems will be used for areas handling potentially radioactive particulate to minimize the possibility of exposure to personnel and the environment. Exhaust ventilation systems will be provided with HEPA filtration to minimize the release of hazardous materials through the exhaust path. The air filtration unit design will allow for routine in-place testing of HEPA filtration systems as outlined on ASME N510.

The adequacy of the filtration system will be confirmed by safety analysis to ensure that airborne radioactive particulate

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WHC-SD-W379-CDR-001 Rev. 0

concentration are ALARA and do not exceed DOE Order 5480.1A requirements during normal, accident and DBA conditions.

## 5.0 HVAC DESIGN CONSIDERATIONS AND STANDARD PRACTICES

### 5.1 Site Design Conditions

The HVAC calculations will be based upon the following design parameters (HPS-SDC 5.1):

#### 5.1.1 Geographical

- a. Altitude: 714 feet.
- b. Latitude: 46° N

#### 5.1.2 Outdoor Design Parameters

##### a. Air Temperature

- 1. For industrial Areas and Non-personnel Comfort Areas

- Normal Plant Operations

Winter: 9°F DB; 8°F WB  
Summer: 101°F DB; 68°F WB

- Safety Class 1 Operations

Winter: -27°F  
Summer: 115°F

- 2. Office Areas

Winter: 12°F DB; 10°F WB  
Summer: 98°F DB; 66°F WB

##### b. Wind Velocity

Winter: 15 mph (25 mph for infiltration)  
Summer: 15 mph (25 mph for infiltration)

##### c. Ground Temperature

The design ground temperature 10 feet below grade: 55°F.

#### 5.1.3 Inside Design Conditions

##### a. Room Temperature

- 1. Canister Storage Vault

During normal operation: (Passive cooling)  
Maximum: < 150°F (vault fully loaded)  
Minimum: -27°F (vault empty)

Post DBA: (passive cooling)  
Maximum: < 150°F  
Minimum: -27°F

2. Canister Storage Operating/Cask Loading Area and Miscellaneous Areas.

During normal operation:  
Maximum: 85°F  
Minimum: 55°F

Post DBA:  
No Temperature Control.

3. Offices

During normal operation:  
Maximum: 78°F  
Minimum: 72°F

Post DBA:  
No Temperature Control.

4. FOS Room

During normal operation:  
Maximum: 72°F +/- 2°F

Post DBA:  
No Temperature Control.

5. Equipment Rooms:

During normal operation:  
Maximum: 85°F  
Minimum: 65°F

Post DBA:  
No Temperature Control.

b. Humidity

1. Canister Storage Vault, Canister Storage Operating Area, Offices and Equipment Rooms:

No control

## 2. FOS Room

During normal operation: 50% +/- 5% RH.

### 5.1.4 Equipment Selection Criteria

The criteria published in ASHRAE Standard 90A and DOE Order 6430.1A, Section 1550-2 for equipment performance and selection will be followed. Equipment operational reliability will be in accordance with DOE Order 6430.1A, Section 1550-99.0.1.

All HVAC equipment will be selected for operation at the altitude specified in the site design conditions.

Air Handling Units will be selected in accordance with DOE Order 6430.1A, Section 1550-2.5.2.

Fans/Motors will be selected in accordance with DOE Order 6430.1A, Section 1550-2.5.3. Fan bearings will be specified for 200,000 hours of service life.

Air Cleaning Devices will be selected in accordance with DOE Order 6430.1A, Section 1550-2.5.5.

Dampers will be selected in accordance with ANSI N509, section 5.9.

Air Distribution Devices such as diffusers, grilles and registers will be selected in accordance with ASHRAE 1993 Fundamentals Handbook, Chapter 31.

### 5.1.5 Air Distribution System Design Requirements

Ductwork, accessories, and support systems will be designed to comply with the following (DOE Order 6430.1A, Section 1550-2.5.6):

- a. ASHRAE 1989 Fundamentals Handbook, Chapter 31.
- b. SMACNA Duct Construction Standards.
- c. SMACNA HVAC Duct Design Manual.
- d. SMACNA Round Industrial Duct Construction Standards.
- e. ERDA 76-21, Nuclear Air Cleaning handbook, Chapter 5.
- f. ANSI N509-1980, Nuclear Power Plant Air Cleaning Units and Components, Section 5.10.

### 5.1.6 Exhaust Stacks

The stack(s) will be lined or constructed with acid-resistant material. An elevated stack will be used for confinement exhaust discharge. Stack height will be sufficient to meet dispersion requirements for normal as well as DBA releases. Stack location and height will also consider intake of the facility. The exhaust

air discharge velocity from the stack will be a minimum of 2500 FPM per 1993 ASHRAE Handbook of Fundamentals.

#### 5.1.7 HVAC Design Interface

The HVAC System will interface with the following systems:

1. Fire Detection and Alarms - Fire Protection and Control Systems
2. Instrumentation and Controls - Control Systems
3. HVAC Equipment Power Supply - Electrical
4. Contamination Confinement - Architectural/Structural
5. Utility Services - Utilities

APPENDIX IV. B

Thermal Analysis for Storing K-Basin Fuel in the HWVP Canister  
Storage Building

## APPENDIX IV. B

### ***THERMAL ANALYSIS FOR STORING K-BASIN FUEL IN THE HWVP CANISTER STORAGE BUILDING***

Following is the rough calculation of heat transfer in the storage vaults. The assumptions as well as calculation results can be used only as a first guess. Detailed calculation using the Computational Fluid Dynamics (CFD) technique is proposed during the Advanced Conceptual Design phase of this project.

K-Basin fuel elements are to be stored in 2 vaults of the canister storage building. Table 1 describes the relation between the number of stored units.

| Unit     | Vault    | Tube | MCO | Assembly | Canister | Cylinder | Element             |
|----------|----------|------|-----|----------|----------|----------|---------------------|
| Storage  | 2 loaded | 440  | 880 | 4400     | 8800     | 17600    | 104848 <sup>1</sup> |
| Vault    |          | 220  | 440 | 2200     | 4400     | 8800     | 52423 <sup>2</sup>  |
| Tube     |          |      | 2   | 10       | 20       | 40       | 280                 |
| MCO      |          |      |     | 5        | 10       | 20       | 140                 |
| Assembly |          |      |     |          | 2        | 4        | 28                  |
| Canister |          |      |     |          |          | 2        | 14                  |
| Cylinder |          |      |     |          |          |          | 7                   |

Table 1. Number of Units in the Storage

Natural convection is considered as an air driving source. Nitrogen is used as an inert media inside the canisters and MCOs.

There are 20% of the fuel elements that are assumed to have maximum heat decay and assumed to have 80% nominal heat decay. Maximum heat load is 482 W per MCO or 3.44 W per element. Nominal heat load is 221 W per MCO or 1.58 W per element. This and other data herein relative to the MCOs are per R.G. Cowan, as defined in the Design Basis, Section 2.8 of the Canister Storage Building Trade Study Final Report, Fluor Daniel, May 1995.

Total heat gain due to the nuclear decay is:

<sup>1</sup>Based on 750 MCOs

<sup>2</sup>Based on 375 MCOs



$$Q_1 = 880 (20\% * 482 + 80\% * 221) = 240,416 \text{ W} = 240.5 \text{ kW}$$

including 10% safety factor

$$Q_n = 240.5 * 1.1 = 264 \text{ kW rounded to 270 kW.}$$

This heat load is used to calculate natural convection for an outside air temperature of 115°F.

To be conservative in the calculation, it is assumed that 280 elements with maximum heat decay of 3.44 W are loaded into a sleeve and located in the last row of the vault having the hottest air temperature.

Maximum allowable temperature of surface of a fuel element is 400°F.

The purpose of this calculation is to find the maximum temperature of the fuel element surface and compare it with the maximum allowable temperature.

The diameter of the hollow outer element ring is assumed the same as the diameter of the outer zirconium cladding (identified as #17 in Figure 1, Fuel Element).

$$D_{17} = 6.1 \text{ cm} = 2.4 \text{ in}$$

The diameter of the inner cylinder of the outer element is

$$D_{14} = 4.4 \text{ cm} = 1.7 \text{ in}$$

Relative diameters for the inner hollow cylinder, are:

$$D_{13} = 3.2 \text{ cm} = 1.25 \text{ in}$$

$$D_{10} = 1.15 \text{ cm} = 0.45 \text{ in}$$

The thicknesses of uranium are:

$$\Delta_{\text{outer}} = 2.4 - 1.7 = 0.7 \text{ in}$$

$$\Delta_{\text{inner}} = 1.25 - 0.45 = 0.8 \text{ in}$$

The uranium total cross-section for a single element is

$$S = \pi / 4 ((D_{17}^2 - D_{14}^2) + (D_{13}^2 - D_{10}^2)) = \pi / 4 ((2.4_{17}^2 - 1.7_{14}^2) + (1.25_{13}^2 - 0.45_{10}^2)) = 3.32 \text{ sq.in}$$

The diameter of the equivalent by cross-section solid uranium cylinder is

$$D = (4 S / \pi)^{0.5} = (4 * 3.32 / \pi)^{0.5} = 2.06 \text{ in}$$

The fuel volume is 243 L (8.58 ft<sup>3</sup>) per MCO, therefore fuel volume per element is

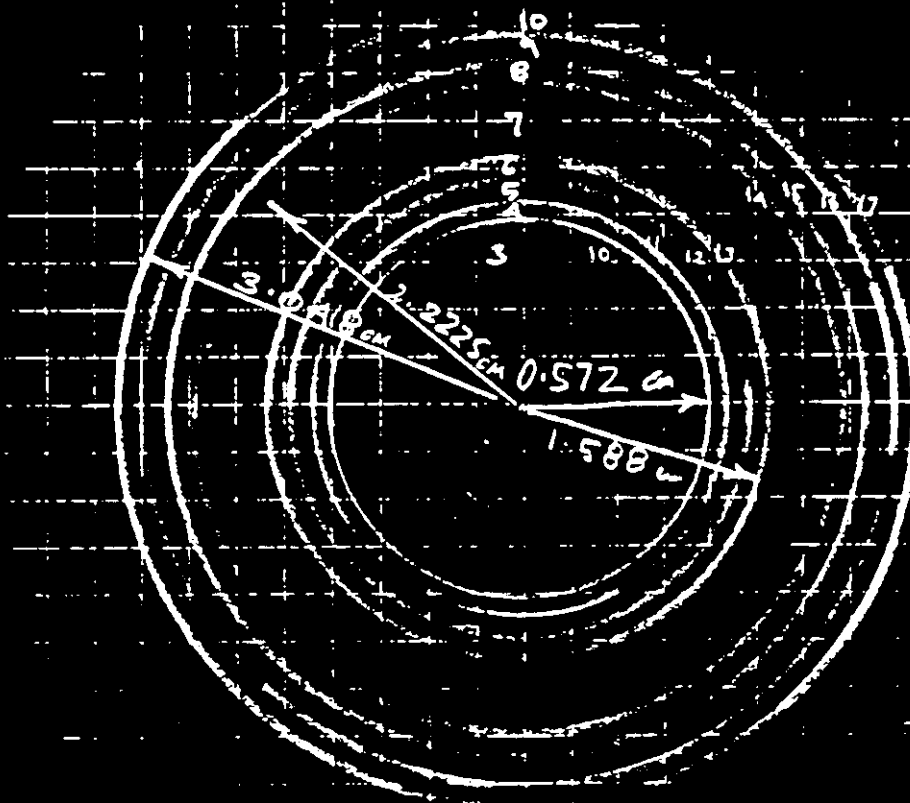


FIGURE 1. FUEL ELEMENT

$$V = 8.58/140 = 0.061 \text{ ft}^3$$

Since the maximum heat decay is 3.44 W which is 11.74 Btu/h, the rate of heat flux is

$$q_x = Q / V = 11.74 / 0.061 = 192.5 \text{ btu/h-ft}^3$$

The heat networking model is developed in order to define the heat transfer zones. Considering a symmetrical heat transfer network the one-dimensional scheme is utilized in the following Figure 2.

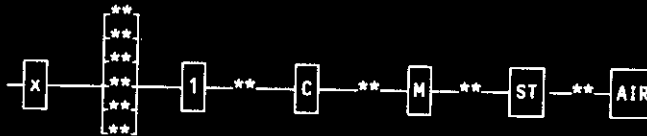


Figure 2. Heat Transfer Network.

- Gap x: between the inner and the outer rings of a fuel element  
 Gap x-1: between the center element and six peripheral fuel elements  
 Gap 1-C: between the peripheral fuel elements and the canister,  
 Gap C-M: between the canister and the MCO,  
 Gap M-ST: between the MCO and the storage tube,  
 Gap ST-AIR: resistance between the storage tube and surrounding air.

Networking resistance factors:

- Zone x; 1 element :  $f_x = 1$   
 Zone x-1; 6 elements:  $f_1 = 1 + 1/6 = 1.17$   
 Other zones in series:  $f = 1$

Heat transfer between two adjacent zones i and i+1. Zones are assumed as flat

$$q_i = q_{i-1} + k (1/f_i) A_i (T_i - T_{i+1}) n_i$$

where,

- $q_{i-1}$  = heat transfer from previous zone, Btu/h  
 $k$  = thermal conductivity coefficient between two zones, btu/h-ft-F  
 $f_i$  = networking resistance factor, dimensionless  
 $A_i$  = heat conduction area for i-zone, sq.ft  
 $T_i$  = (i)-surface temperature, F  
 $T_{i+1}$  = (i+1)-surface temperature, F  
 $n_i$  = number of elements in (i)-zone

It is assumed that the thermal conductivity coefficients are not changing with temperatures.

Following calculations, made for heat transfer areas, consider 80% of actual height of fuel elements and 181" of MCO length (Figure 3).

For zone x, the heat transfer area is calculated equivalent to a single element

$$A_x = \pi(D_{14} + D_{13})/2 * L * 80\% = \pi(1.7 + 1.25)/2 * (181/5) * 0.8 = 134 \text{ sq.in} = 0.93 \text{ sq.ft}$$

The distance between element parts is

$$\delta_x = (D_{14} - D_{13})/2 = (1.7 - 1.25)/2 = 0.23 \text{ in}$$

For zone x-1, the heat transfer area is calculated through 7 elements:

$$A_{x1} = \pi (D_{17} * 7) * (L) * 80\% = \pi (2.4 * 7) (181/5) * 0.8 = 1528 \text{ sq.in} = 10.6 \text{ sq.ft}$$

The distance between surfaces:

$$\delta_{x1} = (0.3 * D_{17})/2 = (0.3 * 2.4)/2 = 0.36 \text{ in}$$

For zone 1-C, the heat transfer area is assumed as an average between 7 elements and cylinder tube surfaces:

$$\begin{aligned} A_{1c} &= (A_{x1} + A_c) / 2 * 80\% = \pi L (6 * D_{x1} + D_c) / 2 * 80\% \\ &= \pi (181/5) (6 * (2.4) + (9)) / 2 * 0.8 = 1064 \text{ sq.in} = 7.39 \text{ sq.ft} \end{aligned}$$

The distance between surfaces:

$$\delta_{1c} = (D_c - (3 * D_{17})/2 = (9 - (3 * 1.7))/2 = 1.99 \text{ in}$$

For zone C-M, the heat transfer area is assumed as an average between the assembly (2 canisters, 28 elements) MCO diameter is 62.5 cm and MCO surfaces:

$$\begin{aligned} A_{cm} &= (4 A_c + A_m) / 2 = \pi L (4 * D_c + D_m) / 2 = \pi ((181/5) * 0.8) (4 * 9 + 24.6) / 2 \\ &= 2757 \text{ sq.in} = 19.14 \text{ sq.ft} \end{aligned}$$

The distance between surfaces:

$$\delta_{cm} = (D_m - 2 D_c)/2 = (24.6 - 2 * 9)/2 = 3.3 \text{ in}$$

For zone M-ST, the heat transfer area is assumed as an average between two MCOs and the sleeve surfaces (total height is 34.4 ft):

$$\begin{aligned} A_{ms} &= (2 A_m + A_s)/2 = \pi L_{Tot} (D_m + D_s) / 2 = \pi (34.4 * 12) (24.6 + 29) / 2 = 34755 \text{ sq.in} \\ &= 241 \text{ sq.ft} \end{aligned}$$

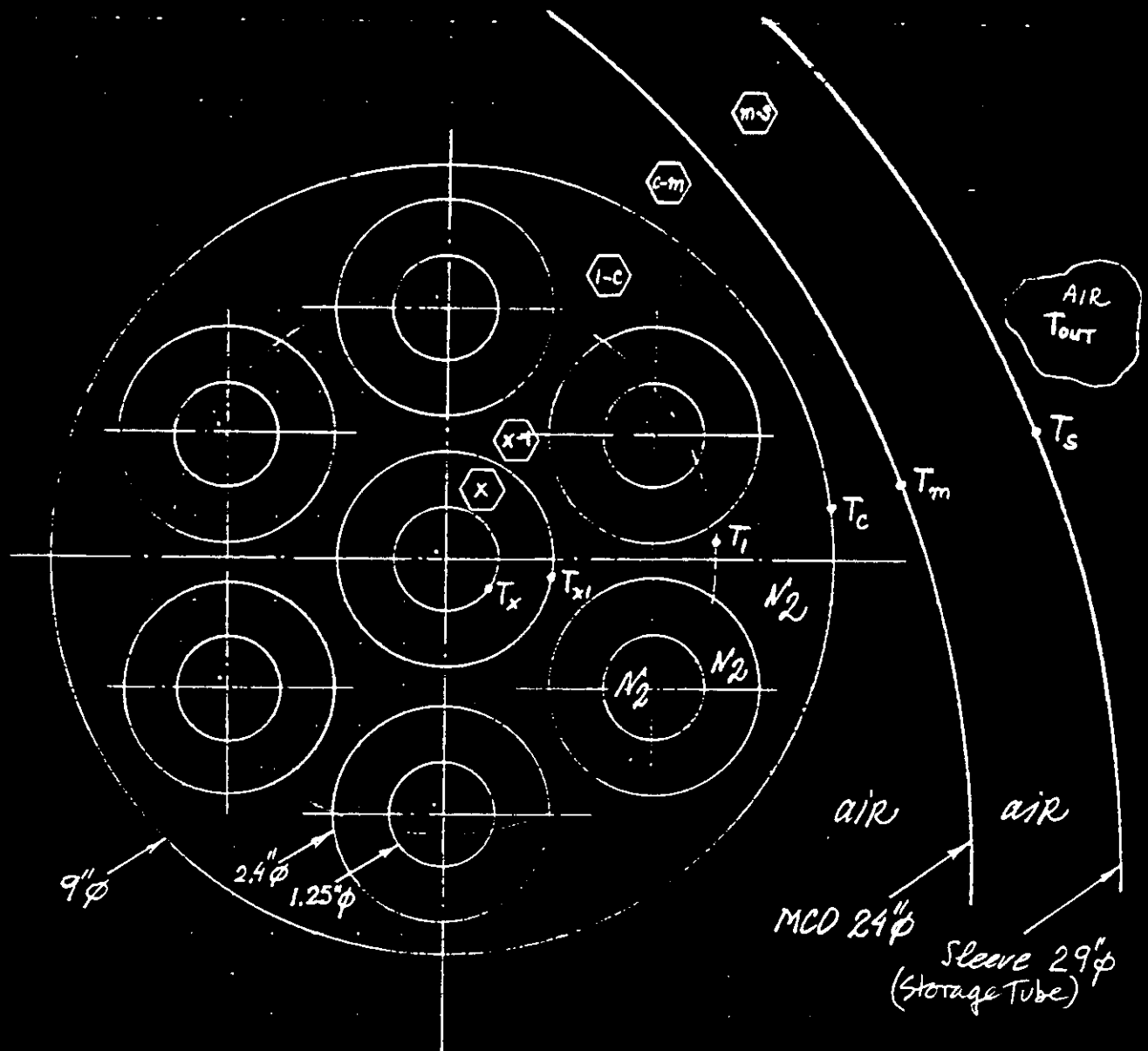


FIGURE 3. HEAT TRANSFER ZONES..

The distance between surfaces:

$$\delta_{ms} = (D_s - D_m)/2 = (29 - 24.6)/2 = 2.5 \text{ in}$$

Heat transfer surface from a sleeve facing the cooling flow is:

$$A_s = \pi L D_s = \pi (34.4 * 12)(29) = 37608 \text{ sq.in} = 261 \text{ sq.ft}$$

Following are assumed emittances for the materials listed (ASHRAE 1989, p.3.8, Table 3., Ref.2b):

Zirconium = 0.25  
Stainless steel = 0.2  
Carbon steel = 0.85

Approximate heat transfer coefficient for nitrogen gaps inside MCO is calculated using different approaches: (1) as presented in FDI calculation No. E350-HV-1802 (Book II)  $h = 0.33 \text{ Btu/h-}^\circ\text{F-ft}^2$ , (2) applying free convection model by calculating the Gragoff, Prandtl, Rayleigh, and Nusselt numbers for enclosed spaces, and (3) using thermal resistance for plane airspace from ASHRAE 1989 Fundamentals, Chapter 22, p.22.2, Table 2. The last approach of using the thermal resistance tables from ASHRAE 1989 is considered as most applicable for this preliminary study since it includes the both convection and thermal radiation and considers less assumptions. As mentioned, more precise calculation using CFD technique will be performed during Advanced Conceptual Design.

For horizontal direction of heat flow,  $90^\circ\text{F}$  mean temperature, the approximate thermal resistance of space for each nitrogen gap depends on gap size. Following thermal resistances are selected from ASHRAE 1989 (p.22.3, Table 2, Ref.2c, with interpolation and extrapolation as conditioned in items "a" and "d"):

For gap x: (see formula, p.22.3)  $h = 0.99 \text{ BTU/}^\circ\text{F-ft}^2\text{-h}$   
For gap x-1: (see formula, p.22.3)  $h = 0.63 \text{ BTU/}^\circ\text{F-ft}^2\text{-h}$   
For gaps 1-C :  $R = 2.48^\circ\text{F-ft}^2\text{-h/Btu}$ ,  $h = 0.40 \text{ BTU/}^\circ\text{F-ft}^2\text{-h}$   
For gaps C-M :  $R = 2.15^\circ\text{F-ft}^2\text{-h/Btu}$ ,  $h = 0.47 \text{ BTU/}^\circ\text{F-ft}^2\text{-h}$   
For gaps M-ST :  $R = 2.30^\circ\text{F-ft}^2\text{-h/Btu}$ ,  $h = 0.43 \text{ BTU/}^\circ\text{F-ft}^2\text{-h}$

Heat transfer coefficient between sleeves and airflow for forced convection is calculated using ASHRAE 1989 Fundamentals (Chapter 3, p.3.15, Ref.2e) as a function of air velocity (assuming vertical plane surfaces with air velocity less than 16 fps)

$$h = 0.99 + 0.21 V$$

Airflow for passive cooling is calculated as a function of stack height, air densities, and system resistances. System hydraulic conductance (K1) is based on system hydraulic characteristics of the vault calculated for the HWVP Project (FDI calculation No. E350-HV-1802, Book II) for airflow at  $Q = 90000 \text{ cfm}$  and  $\Delta P = 0.19 \text{ in.WG}$ . For two vaults this coefficient is  $K1 = 2.65\text{E-}11 \text{ in.WG/cfm}^2$ .

It is assumed that the temperatures of surface from both sides of each material are the same. The only resistance calculated is for the nitrogen gaps between the materials. Following system of simultaneous algebraic equations describes the heat transfer process.

- 1) Heat transfer between the centered and the peripheral parts of a fuel element

$$n_x q = h_x (1/f_x) A_x (T_x - T_{x1})$$

- 2) Heat transfer between surface of a centered fuel element and six surrounding elements

$$n_{x1} q = h_{x1} (1/f_1) A_{x1} (T_{x1} - T_1)$$

- 3) Heat transfer between surface of six elements and a single canister cylinder (zone 1-C)

$$n_1 q = h_{1c} (1/f) A_{1c} (T_1 - T_c)$$

- 4) Heat transfer between surface of assembly and MCO (zone C-M):

$$n_c q = h_{cm} (1/f) A_{cm} (T_c - T_m)$$

- 5) Heat transfer between surface of MCO and storage tube (zone M-ST):

$$n_m q = h_{ms} (1/f) A_{ms} (T_m - T_s)$$

- 6) Heat transfer between surface of storage tube and airflow (zone ST-Air):

$$n_s q = h_{sa} (1/f) A_s (T_s - T_{out})$$

- 7) Heat removed by airflow

$$Q = c_{air} 60 (\rho_{in} + \rho_{out})/2 \text{ (CFM)} (T_{out} - T_{in})$$

The following two equations are used for passive ventilation in order to calculate the airflow.

- 8) Hydraulic resistance of the natural convection system (T-DUCT computer program calculation from NETSAL & Associates)

$$\Delta P = k1 \text{ (CFM)}^2$$

- 9) Stack effect (ASHRAE 1989, p.32.2)

$$P_{stack} = 0.192 (\rho_{in} - \rho_{out}) H$$

These nine equations present nine unknown variables, therefore the problem has a solution. The numerical approach for solving these equations is presented as follow:

Step 0) CFM = initial guess

Step 1)  $T_{out} = T_{in} + Q / (c_{air} 60 (\rho_{in} + \rho_{out})/2 (CFM))$

Step 2)  $\Delta P = k1 (CFM)^2$

Step 3)  $\rho_{out} = 1.75E-7 T_{out}^2 - 0.000166 T_{out} + 0.086$

$\rho_{in} = 1.75E-7 T_{in}^2 - 0.000166 T_{in} + 0.086$

Step 4)  $P_{stack} = 0.192 (\rho_{in} - \rho_{out}) H$

If  $\Delta P = P_{stack}$ , follow to the Step 5. Other wise change the initial guess and repeat iterations from Step 1.

Step 5)  $T_s = T_{out} + n_s q / (h_{sa} A_s)$

Step 6)  $T_m = T_s + n_m q / (h_{ms} A_{ms})$

Step 7)  $T_c = T_m + n_c q / (h_{cm} (1/f) A_{cm})$

Step 8)  $T_1 = T_c + n_1 q / (h_{1c} (1/f_1) A_{1c})$

Step 9)  $T_{x1} = T_1 + n_{x1} q / (h_{x1} (1/f_1) A_{x1})$

Step 10)  $T_x = T_{x1} + n_x q / (h_x (1/f_x) A_x)$

Calculations using these equations are presented in Table 2.

## EVALUATION

This evaluation is based on nitrogen inside MCOs, air inside storage tubes, and cooling air in the vault by natural convection. Manual calculation data are compared with computer data presented on Table 2.

Initial data used in this evaluation.

|                                    |          |                          |
|------------------------------------|----------|--------------------------|
| Inlet air temperature              | $T_{in}$ | = 115°F                  |
| Heat load                          | $Q$      | = 270 kW = 921510 Btu/hr |
| Initial airflow (after iterations) | CFM      | = 53,500 cfm             |
| Hydraulic resistance coeffic.      | $K1$     | = 2.65E-11               |
| Stack height                       | $H$      | = 182 ft                 |



## SSF FUEL STUDY (Conceptual Design)

### Natural Convection

MCO/Nitrogen-Sleeve/Air-880 MCOs-Canister at the end of the vault-5 high/2 vaults  
(BASED ON ASHRAE 1989 TABLE FOR PLANE AIRSPACE, p.22.3, CONVECTION AND RADIATION)

Element Load =  W  
 $q = 11.74$  Btu/hr  
 $T_{in} = 115$  F  
 $q_x = 253.58$  Btu/h-ft<sup>3</sup>  
 $Q_{total} = 270$  kW = 921510 Btu/h  
 $D_{17} = 2.4$  in  
 $D = 2.06$  in  
 $A(2vault) = 1860.00$  ft<sup>2</sup>

#### SLEEVE - AIR:

$V_{air} = 0.48$  fps  
 $A_s = 261$  ft<sup>2</sup>  
 $h_{sa} = 1.09$  Btu/h-ft<sup>2</sup>-F  
 $n = 280$

|                     | ELEMENT                             | ELEM-7ELEM                    | 7EL-CANISTER                  | CAN-MCO(Part)                 | MCO-SLEEVE                    |
|---------------------|-------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Media               | Ur-Zr-Nitrogen                      | Nitrogen                      | Nitrogen                      | Nitrogen                      | Air                           |
| 'Airspace           | Dist= 0.23 in                       | 0.36 in                       | 1.99 in                       | 3.30 in                       | 2.50 in                       |
| Emittance 1         | $\epsilon_1 = 0.25$                 | 0.25                          | 0.25                          | 0.25                          | 0.20                          |
| Emittance 2         | $\epsilon_2 = 0.25$                 | 0.25                          | 0.25                          | 0.20                          | 0.85                          |
| Effective emittance | $E = 0.23$                          | 0.12                          | 0.19                          | 0.23                          | 0.19                          |
| Mean temperature    | $T = 248$ F                         | 245 F                         | 228 F                         | 194 F                         | 160 F                         |
| Temper. difference  | $dT = 4.2$ F                        | 1.8 F                         | 32.1 F                        | 36.9 F                        | 31.4 F                        |
| Area                | $A_x = 0.93$ ft <sup>2</sup>        | 10.6 ft <sup>2</sup>          | 7.39 ft <sup>2</sup>          | 19.14 ft <sup>2</sup>         | 241 ft <sup>2</sup>           |
| Resistance factor   | $f = 1.00$                          | 1.00                          | 1.17                          | 1.00                          | 1.00                          |
| Number of elements  | $n = 0.33$                          | 1.00                          | 7.00                          | 28.00                         | 280.00                        |
| Thermal resistance* | $R =$                               |                               | 2.48 h-ft <sup>2</sup> -F/Btu | 2.15 h-ft <sup>2</sup> -F/Btu | 2.30 h-ft <sup>2</sup> -F/Btu |
| Film coefficient**  | $h = 0.99$ Btu/h-ft <sup>2</sup> -F | 0.63 Btu/h-ft <sup>2</sup> -F | 0.40 Btu/h-ft <sup>2</sup> -F | 0.47 Btu/h-ft <sup>2</sup> -F | 0.43 Btu/h-ft <sup>2</sup> -F |

Natural convection airflow CFM =  cfm

|                      |                                         |             | Actual              | Assumed (10% dT safety)              |
|----------------------|-----------------------------------------|-------------|---------------------|--------------------------------------|
| Hydraulic resistance | $K_1 = 2.65E-11$ in.WG/cfm <sup>2</sup> | Air:        | $T_{in} = 115.0$ F  | = 115 F                              |
| Densities            | $RO_{out} = 0.0671$ lb/ft <sup>3</sup>  | Air:        | $T_{out} = 132.6$ F | = 134 F                              |
|                      | $RO_{in} = 0.0692$ lb/ft <sup>3</sup>   | Sleeve:     | $T_s = 144.1$ F     | = 147 F                              |
| Stack pressure       | $P_{stack} = 0.07524$ in.WG             | MCO:        | $T_m = 175.5$ F     | = <input type="text" value="182"/> F |
| System pressure loss | $dP = 0.07585$ in.WG                    | Canister:   | $T_c = 212.4$ F     | = 222 F                              |
| Pressure difference  | $ddP = 0.0006$ in.WG                    | 7 element:  | $T_1 = 244.5$ F     | = 257 F                              |
|                      |                                         | 1 element:  | $T_{x1} = 246.3$ F  | = 259 F                              |
|                      |                                         | Inner part: | $T_x = 250.5$ F     | = <input type="text" value="264"/> F |

Noice: \* Thermal resistance coefficient is calculated using ASHRAE 1989 Fundamentals tables, p.22.3

Noice: \*\* Thermal conductance coefficient is calculated using ASHRAE 1989 Fundamentals formula, p.22.3 for the airspace less than 0.5 in.

Table 2

Outlet air density (using  $T_{out} = 132.6^{\circ}\text{F}$ )

$$\begin{aligned}\rho_{out} &= 1.75\text{E-}7 T_{out}^2 - 0.000166 T_{out} + 0.086 \\ &= 1.75\text{E-}7 * 132.6^2 - 0.000166 * 132.6 + 0.086 = \\ &= 0.06706 \text{ lb/ft}^3 \quad (\text{compare } 0.0671)\end{aligned}$$

Outlet air temperature is

$$\begin{aligned}T_{out} &= T_{in} + Q / (c_{air} 60 (\rho_{in} + \rho_{out})/2 (\text{CFM})) \\ &= 115 + 921510 / (0.24 * 60 * 0.06706 * 53500) = 132.83^{\circ}\text{F} \quad (\text{compare } 132.6)\end{aligned}$$

Inlet air density is

$$\begin{aligned}\rho_{in} &= 1.75\text{E-}7 T_{in}^2 - 0.000166 T_{in} + 0.086 \\ &= 1.75\text{E-}7 * 115^2 - 0.000166 * 115 + 0.086 = \\ &= 0.0692 \text{ lb/ft}^3 \quad (\text{compare } 0.0692)\end{aligned}$$

System hydraulic resistance

$$\Delta P = k_1 (\text{CFM})^2 = 2.65\text{E-}11 * 53500^2 = 0.0758 \text{ in.WG} \quad (\text{compare } 0.07585)$$

Stack pressure is

$$P_{stack} = 0.192 (\rho_{in} - \rho_{out}) H = 0.192 (0.0692 - 0.0671) 182 = 0.0734 \text{ in.WG} \quad (\text{compare } 0.07524)$$

The difference between pressures is 0.002 in.WG (compare 0.0006).

Film coefficient for heat transfer between storage tube and air is calculated using the following equation

$$h_{sa} = 0.99 + 0.21 * V = 0.99 + 0.21 * 0.48 = 1.091 \text{ Btu/h-ft}^2\text{-}^{\circ}\text{F} \quad (\text{compare } 1.09)$$

where, air velocity is

$$V = 53500 / 1860 / 60 = 0.48 \text{ fpm} \quad (\text{compare } 0.48)$$

Concerning that the ratio  $Gr/Re^2$  can be in the range from 1 to 2, more accurate calculation that includes combined forced and natural heat transfer effect will be analyzed at the next stage of study.

Storage tube temperature is

$$T_s = T_{out} + n_s q / (h_{sa} A_s) = 132.6 + 280 * 11.74 / (1.09 * 261) = 144.15^{\circ}\text{F} \quad (\text{compare } 144.1)$$

MCO surface temperature is

$$T_m = T_s + n_m q / (h_{ms} A_{ms}) = 144.1 + 280 * 11.74 / (0.43 * 241) = 175.82^{\circ}\text{F}$$

(compare 175.5)

Canister surface temperature

$$T_c = T_m + n_c q / (h_{cm} (1/f) A_{cm}) = 175.5 + 28 * 11.74 / (0.47 (1) 19.14) = 212.0^{\circ}\text{F}$$

(compare 212.4)

Canister internal temperature (approximate, first internal stage)

$$T_1 = T_c + n_1 q / (h_{1c} (1/f_1) A_{1c}) = 212.4 + 7 * 11.74 / (0.4 (1/1.17) 7.39) = 244.93^{\circ}\text{F}$$

(compare 244.5)

Canister outer part heat conductivity is calculated using formula from ASHRAE

$$h_c = 0.159 (1 + 0.0016 T_1) / l = 0.159 (1 + 0.0016 * 246.3) / 0.36 = 0.616$$

(compare 0.62)

Canister outer part temperature

$$T_{x1} = T_1 + n_{x1} q / (h_x (1/f_x) A_{x1}) = 244.5 + 1 * 11.74 / (0.62 (1) 10.6) = 246.26^{\circ}\text{F}$$

(compare 246.3)

Canister inner part heat conductivity is calculated using formula from ASHRAE

$$h_c = 0.159 (1 + 0.0016 T_1) / l = 0.159 (1 + 0.0016 * 250.5) / 0.23 = 0.968$$

(compare 0.99)

Canister inner part temperature

$$T_x = T_{x1} + n_x q / (h_x (1/f_x) A_x) = 246.3 + 0.33 * 11.74 / (0.99 (1) 0.93) = 250.5^{\circ}\text{F}$$

(compare 250.5)

## APPENDIX V

### Radiation Protection Engineering Data

- A. Preliminary ALARA Analysis
- B. CSB/SSF ALARA Program (Draft) - Outline Table of Contents
- C. MCO Source Development and Basis for Shielding Analysis

✓ 1a

WHC-SD-W379-CDR-001 Rev.0

**APPENDIX V. A**

**Preliminary ALARA Analysis**

✓ ii-A

WHC-SD-W379-CDR-001 Rev. 0

## APPENDIX V. A

### Preliminary ALARA Analysis

#### A. Introduction

There are two cases to be investigated in this preliminary ALARA analysis. The first case is whether the contact dose rate for the multi-canister overpack (MCO) shielding cask should be 20 mrem/h or 0.5 mrem/h. The second case to be examined is whether the contact dose rate for the multi-canister overpack (MCO) shielding cask should be 0.5 mrem/h or 0.2 mrem/h.

The first case will ignore the required MCO neutron shield. The reason for this is that the neutron shield and the final one inch of steel shielding are constant to any weight differential calculation and therefore, are not part of any cost differential calculation.

#### B. Cost differentials

This analysis will only consider two cost drivers in comparing the difference between a 20 mrem/h and a 0.5 mrem/h shielding cask contact dose rate. The addition of more cost drivers is not expected to alter the findings of this analysis. This analysis will examine the differential crane and shield cost.

Fluor Daniel Inc. (FDI) Shielding estimates that a 20 mrem/h contact dose rate shield requires 10 inches of steel shielding and a 0.5 mrem/h contact dose rate shield requires 13 inches of steel shielding. The estimated weight of a 10 inch shielding cask (ignoring caps which are also a constant) is 30.48 tons. The estimated weight of a 13 inch shielding cask is 42.76 tons.

FDI Estimating states that the fabricated shield cost is \$3000/ton. Thus, the cost of a 10 inch shielded cask is as follows:

$$\$3000/\text{ton} \times 30.48 \text{ tons} = \$91,440.$$

The cost of a 13 inch shielded cask is as follows:

$$\$3000/\text{ton} \times 42.76 \text{ tons} = \$128,280.$$

The differential cost is as follows:

$$\$128,280 - \$91,440 = \$36,840.$$

FDI Estimating states that the installed cost of a 80 ton crane is \$1,573,000 and that the installed cost of a 110 ton crane is \$1,936,000. The cost differential is as follows:

$$\$1,936,000 - \$1,573,000 = \$363,000.$$

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Therefore, the total cost differential used in this analysis is as follows:

$$\$363,000 + \$36,840 = \$399,840.$$

### C. Case 1 Analysis

The total exposure dose associated with the 20 mrem/h shield cask (case one) must now be estimated. FDI Shielding and Health Physics (HP) estimate that the exposure rate at a distance of 3.3 feet (1 meter) from a shield cask with a contact dose rate of 20 mrem/h is 7.3 mrem/h. The 3.3 feet distance chosen for this analysis is very conservative since most people cannot reach this far. A more reasonable distance would be 2 feet with an estimated dose rate of 9.0 mrem/h. However, the 3.3 feet will be maintained so that there is no apparent bias in this analysis. FDI Shielding and HP estimate that the exposure rate at a distance of 3.3 feet (1 meter) from a shielded cask with a contact dose rate of 0.5 mrem/h is 0.18 mrem/h. Therefore, the differential dose rate is 7.12 mrem/h (7.3 mrem/h - 0.18 mrem/h).

The following exposure durations are taken from the *CSB Trade Studies Final Report, Base Case Concept 2D Material Flow Diagrams, Figure 2-10, Steps 1 through 10 and Figure 2-12, Steps 5 through 7:*

| <u>Operational Sequence</u>                                           | <u>Step Nos.</u>             | <u>Duration<br/>(Hours)</u> | <u>@20mrem/h*<br/>(mrem)</u> |
|-----------------------------------------------------------------------|------------------------------|-----------------------------|------------------------------|
| From hot cell to tube                                                 | 5 thru 7                     | 2.5                         | 17.80                        |
| From tube to stabilization facility                                   | 7 thru 5                     | 2.5                         | 17.80                        |
| From stabilization facility to tube                                   | 7 thru 5                     | 2.5                         | 17.80                        |
| From tube to final disposition<br>(From tube to hot cell to rail car) | 7 thru 5<br>and<br>10 thru 1 | 14.5                        | 103.24                       |
| TOTAL LIFETIME FACILITY DOSE FOR BASIC MOVEMENTS                      |                              |                             | 156.64                       |

\* The multiplier is the differential dose rate of 7.12 mrem/h at 3.3 feet not the contact dose rate of 20 mrem/h.

|                                                       |                             |   |       |
|-------------------------------------------------------|-----------------------------|---|-------|
| <u>Servicing</u>                                      |                             |   |       |
| Round trip (from the tube to the hot cell and return) | 7 thru 5<br>and<br>5 thru 7 | 5 | 35.6  |
| Servicing in cask transfer tunnel                     | Estimated                   | 2 | 14.24 |
| TOTAL DOSE FOR ONE SERVICE CYCLE                      |                             |   | 49.84 |

In keeping with the conservative nature of this analysis, it is assumed that only two people are on the CSB Operating Floor

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whenever the shielded cask is present. During operations, there would likely be more workers present.

|                         | Basic<br>Movements<br>(rem) | Minimum Dose:<br>Basic Movements +<br>One Service<br>(rem) | Maximum Dose:<br>Basic Movements +<br>One Service/vr x 6<br>(rem) |
|-------------------------|-----------------------------|------------------------------------------------------------|-------------------------------------------------------------------|
|                         |                             | 0.15664                                                    | 0.15664                                                           |
|                         |                             | 0.04984                                                    | 0.29904                                                           |
|                         |                             | -----                                                      | -----                                                             |
| One MCO                 | 0.15664                     | 0.20648                                                    | 0.45568                                                           |
| 750 MCOs                | 117.48                      | 154.86                                                     | 341.76                                                            |
| 750 MCOs x<br>2 persons | 234.96                      | 309.72                                                     | 683.52                                                            |

In accordance with the CSB/SSF ALARA Program (see Appendix V. B.), if the cost per person-rem is \$30,000 or less then the ALARA dose reduction modification is mandatory. At this point in this analysis, there is sufficient information to determine if there is a mandatory modification required to reduce the contact dose level from 20 mrem/h to 0.5 mrem/h.

$$\$399,840/309.72 = \$1290.97 \text{ per person-rem}$$

This cost per person-rem is not only below the ALARA Program level, it is even below the original WHC value of \$2500 per person-rem. Therefore, this modification is mandatory. The modification remains mandatory, even using the extremely conservative numbers generated above.

$$\$399,840/234.96 = \$1701.74 \text{ per person-rem}$$

$$\$399,840/683.52 = \$584.97 \text{ per person-rem}$$

#### D. Case 2 Analysis

As stated above, the second case to be examined in this preliminary draft ALARA analysis is whether the contact dose rate for the MCO shielding cask should be 0.5 mrem/h or 0.2 mrem/h. Since both of these casks would use the same 110 ton crane, the only cost driver to be analyzed is the cost differential of the casks. FDI Shielding estimates that a 0.2 mrem/h shielding cask contact dose rate requires 14 inches of steel. The estimated weight of a 14 inch shielding cask is 47.17 tons. From above, the differential weight is 4.41 tons (47.17 tons - 42.76 tons). The cost differential is as follows:

$$\$3000/\text{ton} \times 4.41 \text{ tons} = \$13,230$$

As stated above, FDI Shielding and HP estimate that the exposure rate at a distance of 3.3 feet (1 meter) from a shielded cask with

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a contact dose rate of 0.5 mrem/h is 0.18 mrem/h. Shielding and HP also estimate that the exposure rate at a distance of 3.3 feet (1 meter) from a shielded cask with a contact dose rate of 0.2 mrem/h is 0.073 mrem/h. Thus, the differential dose rate is 0.107 mrem/h (0.18 mrem/h - 0.073 mrem/h).

The following exposure durations are taken from the CSB Trade Studies Final Report, Base Case Concept 2D Material Flow Diagrams, Figure 2-10, Steps 1 through 10 and Figure 2-12, Steps 5 through 7:

| <u>Operational Sequence</u>                                           | <u>Step Nos.</u>             | <u>Duration<br/>(Hours)</u> | <u>@0.5 mrem/h*<br/>(mrem)</u> |
|-----------------------------------------------------------------------|------------------------------|-----------------------------|--------------------------------|
| From hot cell to tube                                                 | 5 thru 7                     | 2.5                         | 0.2675                         |
| From tube to stabilization facility                                   | 7 thru 5                     | 2.5                         | 0.2675                         |
| From stabilization facility to tube                                   | 7 thru 5                     | 2.5                         | 0.2675                         |
| From tube to final disposition<br>(From tube to hot cell to rail car) | 7 thru 5<br>and<br>10 thru 1 | 14.5                        | 1.5515                         |
| TOTAL LIFETIME FACILITY DOSE FOR BASIC MOVEMENTS                      |                              |                             | 2.3540                         |

\* The multiplier is the differential dose rate of 0.107 mrem/h at 3.3 feet not the contact dose rate of 0.5 mrem/h.

#### Servicing

|                                                       |                             |   |        |
|-------------------------------------------------------|-----------------------------|---|--------|
| Round trip (from the tube to the hot cell and return) | 7 thru 5<br>and<br>5 thru 7 | 5 | 0.5350 |
| Servicing in cask transfer tunnel                     | Estimated                   | 2 | 0.2140 |
| TOTAL DOSE FOR ONE SERVICE CYCLE                      |                             |   | 0.7490 |

In keeping with the conservative nature of this analysis, it is assumed that the same two people as above are on the CSB Operating Floor whenever the shielded cask is present. During operations, there would likely be more workers present.

|                         | <u>Basic<br/>Movements<br/>(mrem)</u> | <u>Minimum Dose:<br/>Basic Movements +<br/>One Service<br/>(mrem)</u> | <u>Maximum Dose:<br/>Basic Movements +<br/>One Service/yr x 6<br/>(mrem)</u> |
|-------------------------|---------------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------------------------|
|                         |                                       | 2.354                                                                 | 2.354                                                                        |
|                         |                                       | 0.749                                                                 | 4.494                                                                        |
|                         |                                       | -----                                                                 | -----                                                                        |
| One MCO                 | 2.354                                 | 3.103                                                                 | 6.848                                                                        |
| 750 MCOs                | 1765.5                                | 2327.25                                                               | 5136                                                                         |
| 750 MCOs x<br>2 persons | 3531                                  | 4654.5                                                                | 10272                                                                        |

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In accordance with the CSB/SSF ALARA Program (see Appendix V.B.) if the cost per person-rem is \$30,000 or less then the ALARA dose reduction modification is mandatory. At this point in this analysis, there is sufficient information to determine if there is a mandatory modification required to reduce the contact dose level from 0.5 mrem/h to 0.2 mrem/h.

$$\$13,230/4.6545 = \$2,842.41 \text{ per person-rem}$$

This cost per person-rem is also below the ALARA Program level, and below the recommended WHC value of \$30,000 per person-rem. Therefore, this modification is also mandatory. The modification also remains mandatory, even using the extremely conservative numbers generated above.

$$\$13,230/3.531 = \$3746.81 \text{ per person-rem}$$

$$\$13,230/10.272 = \$1287.97 \text{ per person-rem}$$

As a result of this preliminary ALARA analysis, it is mandatory that FDI design an optimized shield cask with a contact dose rate that does not exceed 0.2 mrem/h for both neutrons and gamma radiation.

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SNF CSB Conceptual Design Report  
Westinghouse Hanford Company  
WHC P.O. TVW-SVV-370252

Fluor Daniel, Inc.  
Government Services  
Contract 04436307

**APPENDIX V. B**

CSB/SSF ALARA Program (Draft)  
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APPENDIX V. C

MCO SOURCE DEVELOPMENT AND  
BASIS FOR SHIELDING ANALYSES FOR  
SPENT NUCLEAR FUEL CANISTER STORAGE BUILDING  
STAGING AND STORAGE FACILITY CONCEPTUAL DESIGN

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## INTRODUCTION

The various aspects of the MCO source development include the following main elements (based primarily on the  $\alpha$ -,  $\beta$ -,  $\gamma$ - and n-"decay" of the radioisotopes comprising the source):

1. The geometry and materials of the seven N-Fuel element canisters and the combined 2 x 5 high canisters that comprise the Multi-Canister Overpack (MCO).
2. Definition of the radioisotopes in the source (based on N-Reactor spent fuel).
3. The gamma radiation source based on the gamma decay of the radioisotopes.
4. The beta radiation energy dependent spectra based on the beta decay of the radioisotopes.
5. The beta-induced bremsstrahlung radiation from the slowing down of the beta radiation in the materials of the MCO.
6. The neutron spectra of the MCO based on 1) the spontaneous fission of the uranium and transuranic radioisotopes, and 2) the ( $\alpha$ ,n) reaction of the  $\alpha$ -decay particles of the radioisotopes interacting with the low-Z (atomic number) materials in the MCO.

The following subsections discuss the development of the MCO radiation source components that are used in the conceptual design of the CSB/SSF.

### 1. Geometry and Materials

#### 1.1 MCNP-4A MCO Model

The description of the MCO and the shipping cask is based on Reference 1. Figures 1 through 4 on the following pages show the computer model generated by the MCNP-4A Monte Carlo computer program used for radiation and shielding analysis (Reference 2).

MCNP-4A normally has a very efficient way to input the model geometry data by using "repeated universes" to describe multiple similar elements within the model (e.g., the seven similar N-Fuel elements, the four similar canisters per layer and the five similar layers per MCO). However, for beta/bremsstrahlung radiation analysis, MCNP-4A requires explicit geometry for the analysis and thus a "brute force" MCNP-4A full detailed model is required for the beta radiation related analysis. This requires a somewhat laborious generation of the MCNP-4A input file to describe

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the MCO N-Fuel geometry in reasonable detail resulting in over 1320 lines of input specification for the MCO.

## 1.2 Average Density of MCO Internals

Based on the MCNP-4A modeled MCO configuration, the masses and volumes of the various components of the MCO can be obtained. The output file from the MCNP-4A above modeled MCO provides the masses and volumes of the individual components. To a first approximation (within the accuracy of the model), the total mass and volume of the elements within the MCO can be used to determine the average density of the "source" region of the MCO. The MCNP-4A output file (MCNP-4A Output Table 60) was merged with Lotus 1-2-3 and those modeled components for the MCO internals were summed to give the total mass and volume within the individual N-Fuel canisters and the MCO. The results are:

N-Fuel Canister (Source) Density = 10.3996 g/cm<sup>3</sup>

MCO (Source) Density = 1.07348 g/cm<sup>3</sup>

This can be compared to the average MCO internal density based on data provided in the Performance Specs. Using the data of Table 3.2.2.1.2.2-2 "MCO General Attributes" in the Performance Specification. The total MCO weight is 5927 kg and the MCO volume is 1265 L. Subtracting the approximate weight of the MCO container and top shield (estimated to be 1,164 kg) as well as the water weight of 984 kg gives an MCO internal net weight of 3779 kg. Dividing this weight by the MCO volume gives an average density of 2.99 g/cm<sup>3</sup>. It should be noted that an average MCO internal density of 3.99 g/cm<sup>3</sup> was used for the CSB Feasibility and Trade Studies. Thus, the above MCNP-4A obtained average density is conservative from a radiation analysis point of view (lower internal density means less source self-absorption of the radiation and higher external radiation fields. A conservative MCO source density value of between 1.07 g/cm<sup>3</sup> and 2.99 g/cm<sup>3</sup>, say, 2.0 g/cm<sup>3</sup> should be used.

The MCO conservative source region density value of 1.07 g/cm<sup>3</sup> is used in some subsequent calculations for the gamma, beta (bremsstrahlung), and neutron [both from spontaneous fission and ( $\alpha$ ,n) reactions] radiation sources, and 2.0 g/cm<sup>3</sup> is used for other shielding calculations (e.g., CSB Operating Floor thickness).

## 1.3 General Material Properties

In addition to the specific source region densities, other material properties are required to perform the radiation and shielding analyses. Typically these material properties are built into the shielding codes. However, MCNP-4A requires that all material

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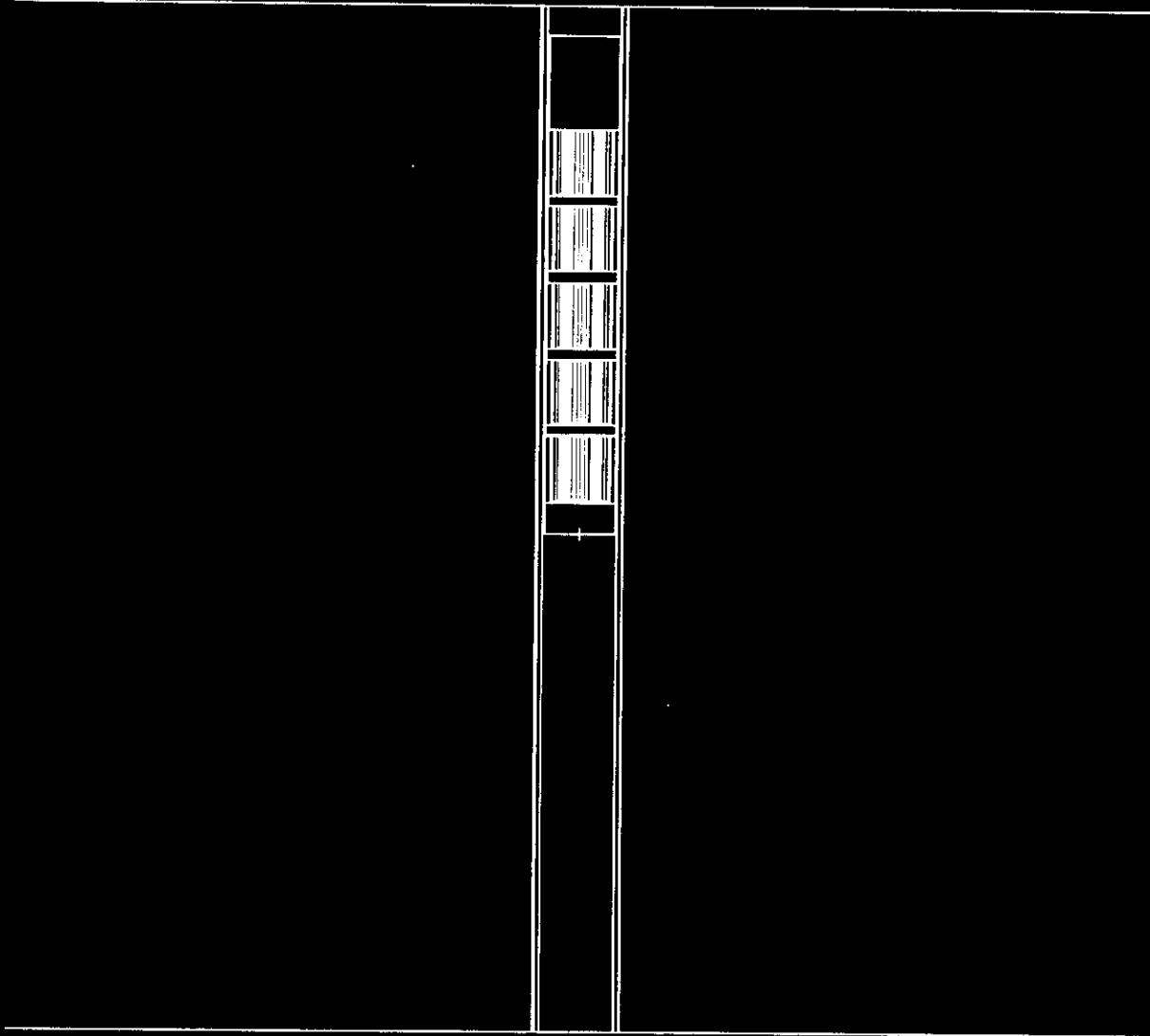


FIGURE 1: MCNP-4A MODEL OF TOP MCO IN CSB STORAGE TUBE

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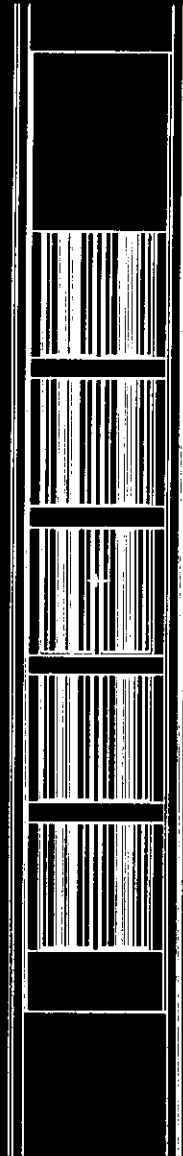


FIGURE 2: MCNP-4A MODEL OF MCO (2 X 5 HIGH)

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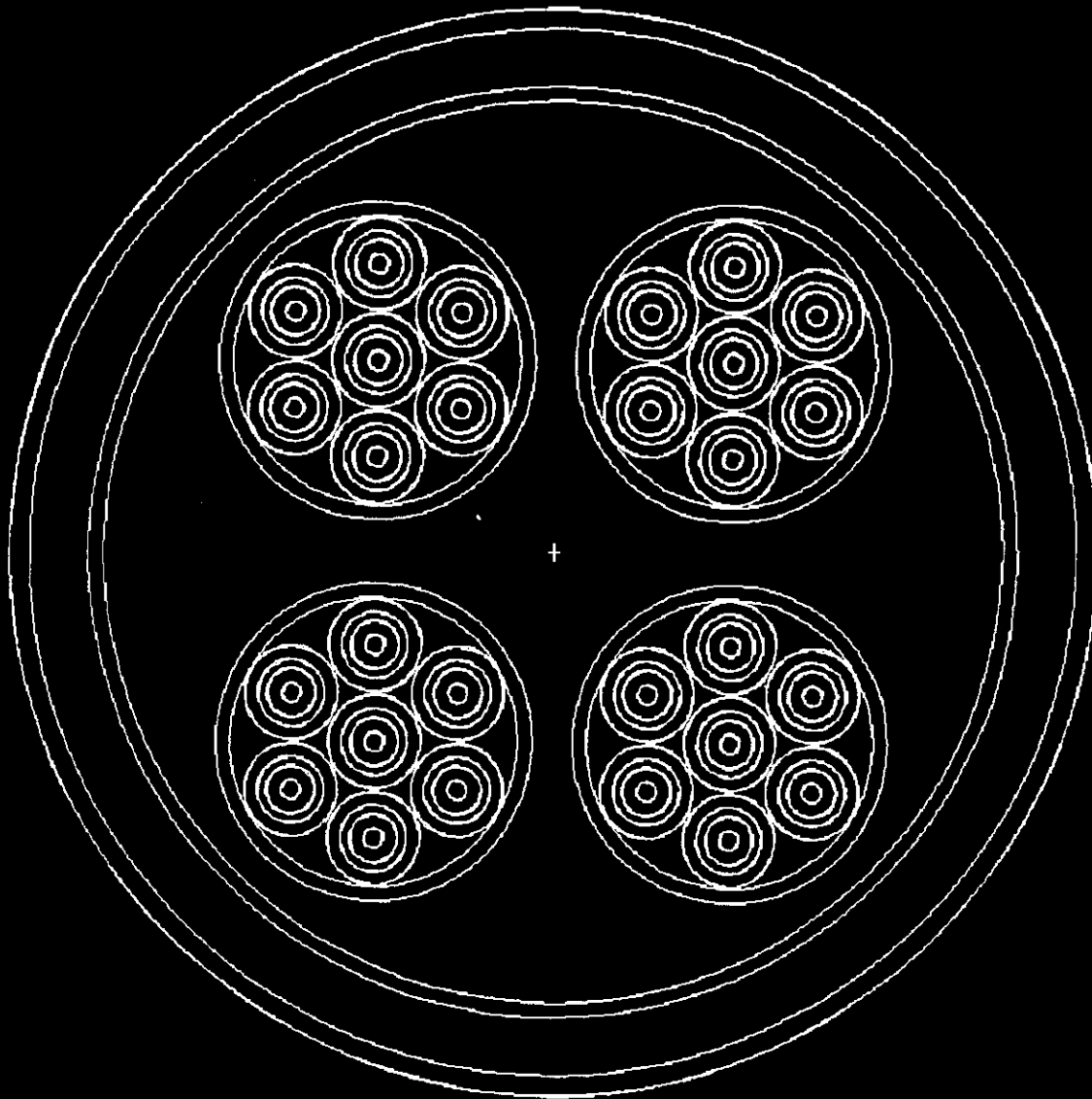


FIGURE 3: MCNP-4A MODEL OF MCO IN STORAGE TUBE (PLAN VIEW)

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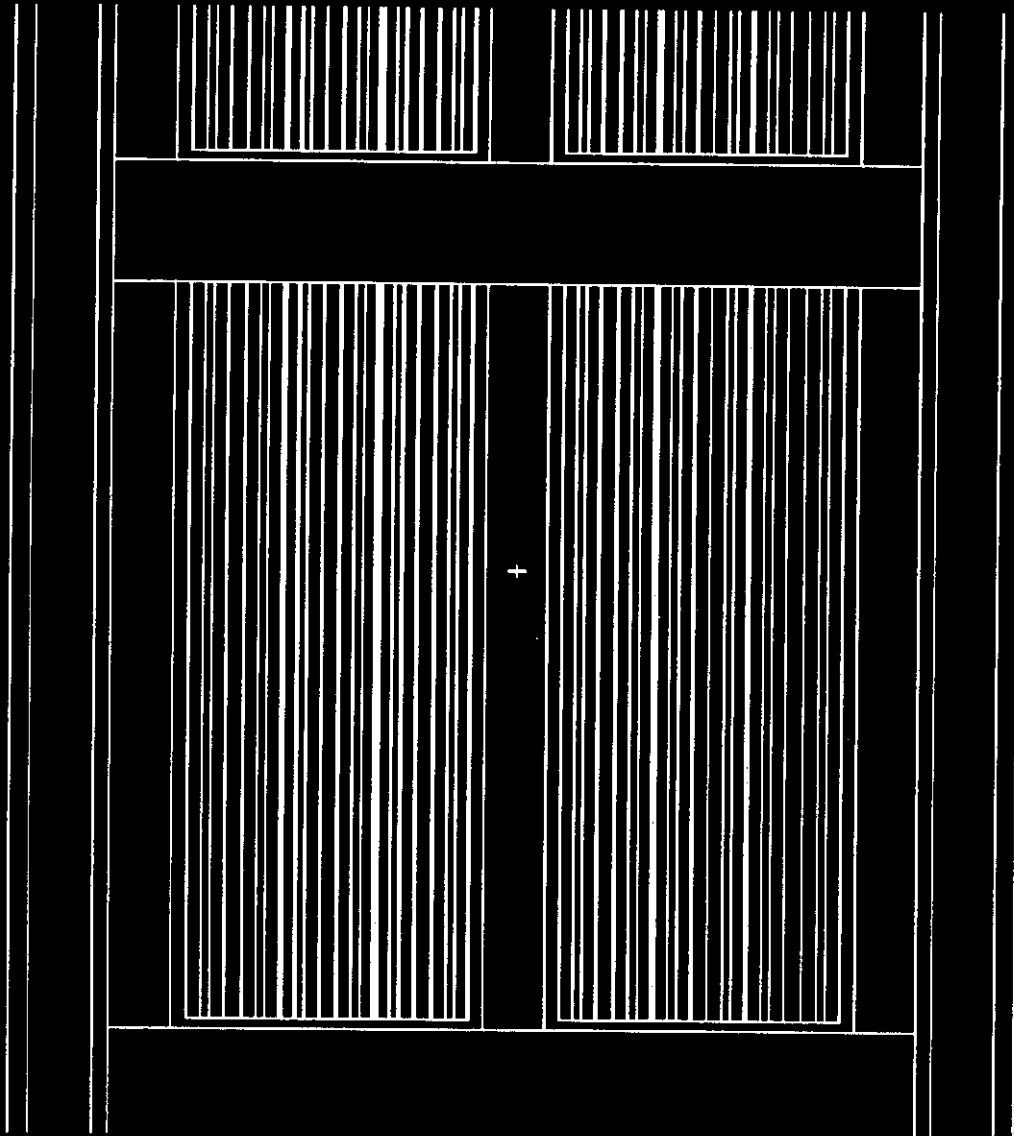


FIGURE 4: MCNP-4A MODEL OF MCO (ELEVATION THROUGH CANISTER CENTERLINE)

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properties be defined as part of the input data. The MCNP-4A material specifications require a detailed breakdown of the material constituents. In order to provide a consistent set of materials, the following table of materials used by the Fluor Daniel team is given as reference (Table 1).

## 2. MCO Radioisotope Source

In order to develop a radiation source derived from the  $\alpha$ ,  $\beta$ ,  $\gamma$  and neutron "decay" of radioisotopes in the source, an accurate description of the radioisotope content of the Spent Nuclear Fuel (SNF) must be provided.

Table 1  
Densities of Some Materials

| <u>Material</u>      | <u>Density (g/cc)</u> | <u>Material</u>           | <u>Density (g/cc)</u> |
|----------------------|-----------------------|---------------------------|-----------------------|
| Air                  | 0.00122               | Nickel                    | 8.9                   |
| Aluminum             | 2.702                 | Tin                       | 7.3                   |
| Carbon               | 2.0                   | Titanium                  | 4.5                   |
| Concrete (Ordinary)  | 2.35                  | Tungsten                  | 19.3                  |
| Concrete (For Anal.) | 2.24                  | Steel (Stainless)         | 7.83                  |
| Concrete (Magnetite) | 3.76                  | Sulfur                    | 2.07                  |
| Hydrogen             | 0.0008                | Urania (UO <sub>2</sub> ) | 11.0                  |
| Iron (Carbon/Pure)   | 7.86                  | Uranium                   | 18.7                  |
| Lead                 | 11.3                  | Water                     | 1.0                   |
| Lithium              | 0.532                 | Zirconium                 | 6.5                   |

The fractional densities for compound materials used in this study are listed in Table 1.A. The atom densities for some common materials are also listed in Table 1.A. The physical properties of the materials used for the shields and source are variables which can influence the results of a calculation. The buildup factors and the attenuation coefficients as calculated, or as included in MicroShield, depend on the physical properties of the materials. In order to establish consistency, the default densities in MicroShield 4.10 were used, where applicable.

### 2.1 Basis for Radioisotopic Source

The basis for the radioisotopes used in the Conceptual Design radiation and shielding analyses are references 7 and 8. Reference 7, "Performance Specification," gives the primary description. However, a more detailed breakdown of the individual radioisotopes is required to effectively run the radiation analysis codes. Reference 8 is used to develop a more detailed description of the radioisotope constituents. Table 2 shows the results of spreadsheet merging of the information from both references 7 and 8. The method used was to group the unspecified radioisotopes from the Performance Specification given as "All Other" into the same

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Table 1.A  
 Composition of Materials Used in Radiation  
 Shielding Calculations  
 (Given as Fractional Densities in g/cm<sup>3</sup>)

| Atomic<br>Number | Element         | Air        | Water   | Stainless<br>Steel<br>304L<br>ASTM A240 |
|------------------|-----------------|------------|---------|-----------------------------------------|
| 1                | H               |            | 0.11111 |                                         |
| 5                | B <sup>10</sup> |            |         |                                         |
| 5                | B <sup>11</sup> |            |         |                                         |
| 6                | C               | 0.00000017 |         | 0.0023                                  |
| 7                | N               | 0.00092132 |         |                                         |
| 8                | O               | 0.00028276 | 0.88889 |                                         |
| 11               | Na              |            |         |                                         |
| 12               | Mg              |            |         |                                         |
| 13               | Al              |            |         |                                         |
| 14               | Si              |            |         | 0.0587                                  |
| 15               | P               |            |         | 0.0035                                  |
| 16               | S               |            |         | 0.0023                                  |
| 18               | Ar              | 0.00001575 |         |                                         |
| 19               | K               |            |         |                                         |
| 20               | Ca              |            |         |                                         |
| 22               | Ti              |            |         |                                         |
| 24               | Cr              |            |         | 1.5660                                  |
| 25               | Mn              |            |         | 0.1566                                  |
| 26               | Fe              |            |         | 5.1009                                  |
| 28               | Ni              |            |         | 0.9396                                  |
| Total            |                 | 0.00122    | 1.00    | 7.8299                                  |

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| Table 1.A (Continued)                                                                          |                 |                         |         |                                               |
|------------------------------------------------------------------------------------------------|-----------------|-------------------------|---------|-----------------------------------------------|
| Composition of Materials Used in Radiation Shielding Calculations<br>(Given as Atom Fractions) |                 |                         |         |                                               |
| Atomic Number                                                                                  | Element         | Air                     | Water   | Stainless Steel<br>304L ASTM A240<br>(Ref. 3) |
| 1                                                                                              | H               |                         | 0.6648  |                                               |
| 5                                                                                              | B <sup>10</sup> |                         |         |                                               |
| 5                                                                                              | B <sup>11</sup> |                         |         |                                               |
| 6                                                                                              | C               | 0.00017                 |         | 0.00134                                       |
| 7                                                                                              | N               | 0.78438                 |         |                                               |
| 8                                                                                              | O               | 0.21075                 | 0.33516 |                                               |
| 11                                                                                             | Na              |                         |         |                                               |
| 12                                                                                             | Mg              |                         |         |                                               |
| 13                                                                                             | Al              |                         |         |                                               |
| 14                                                                                             | Si              |                         |         | 0.01464                                       |
| 15                                                                                             | P               |                         |         | 0.00079                                       |
| 16                                                                                             | S               |                         |         | 0.00050                                       |
| 18                                                                                             | Ar              | 0.0047                  |         |                                               |
| 19                                                                                             | K               |                         |         |                                               |
| 20                                                                                             | Ca              |                         |         |                                               |
| 22                                                                                             | Ti              |                         |         |                                               |
| 24                                                                                             | Cr              |                         |         | 0.21093                                       |
| 25                                                                                             | Mn              |                         |         | 0.01996                                       |
| 26                                                                                             | Fe              |                         |         | 0.6397                                        |
| 28                                                                                             | Ni              |                         |         | 0.11213                                       |
| Density,<br>atoms/barn-cm                                                                      |                 | $5.0513 \times 10^{-5}$ | 0.0998  | 0.085989                                      |

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| Table 1.A (Continued)                                                                          |                 |              |                                      |                        |
|------------------------------------------------------------------------------------------------|-----------------|--------------|--------------------------------------|------------------------|
| Composition of Materials Used in Radiation Shielding Calculations<br>(Given as Atom Fractions) |                 |              |                                      |                        |
| Atomic Number                                                                                  | Element         | Polyethylene | Ordinary Shielding Concrete (Ref. 4) | ICPP Concrete (Ref. 5) |
| 1                                                                                              | H               | 0.6648       | 0.1679                               | 0.1034                 |
| 5                                                                                              | B <sup>10</sup> |              |                                      |                        |
| 5                                                                                              | B <sup>11</sup> |              |                                      |                        |
| 6                                                                                              | C               | 0.33515      | 0.00139                              | 0.02174                |
| 7                                                                                              | N               |              |                                      |                        |
| 8                                                                                              | O               |              | 0.5619                               | 0.59114                |
| 11                                                                                             | Na              |              | 0.0118                               | 0.00747                |
| 12                                                                                             | Mg              |              | 0.00140                              |                        |
| 13                                                                                             | Al              |              | 0.02141                              | 0.02174                |
| 14                                                                                             | Si              |              | 0.2057                               | 0.20654                |
| 15                                                                                             | P               |              |                                      |                        |
| 16                                                                                             | S               |              |                                      | 0.00068                |
| 18                                                                                             | Ar              |              |                                      |                        |
| 19                                                                                             | K               |              | 0.00564                              |                        |
| 20                                                                                             | Ca              |              | 0.01863                              | 0.04212                |
| 22                                                                                             | Ti              |              |                                      |                        |
| 24                                                                                             | Cr              |              |                                      |                        |
| 25                                                                                             | Mn              |              |                                      |                        |
| 26                                                                                             | Fe              |              | 0.00426                              | 0.00516                |
| 28                                                                                             | Ni              |              |                                      |                        |
| Density, atoms/barn-cm                                                                         |                 | 0.1231       | 0.08305                              | 0.0747                 |

| Table 1.A (Continued)                                                                                                              |         |           |          |              |
|------------------------------------------------------------------------------------------------------------------------------------|---------|-----------|----------|--------------|
| Composition of Materials Used in Shielding and Criticality Calculations<br>(Given as Atom Densities in atoms/barn-cm; from Ref. 6) |         |           |          |              |
| Atomic Number                                                                                                                      | Element | Hastelloy | Kaowool  | Burglas 1200 |
| 5                                                                                                                                  | B       |           |          | 0.0002769    |
| 6                                                                                                                                  | C       | 0.00041   |          |              |
| 8                                                                                                                                  | O       |           | 0.000904 | 0.003621     |
| 12                                                                                                                                 | Mg      |           |          | 0.0001195    |
| 13                                                                                                                                 | Al      |           | 0.000256 | 0.0003307    |
| 14                                                                                                                                 | Si      | 0.00176   | 0.000250 | 0.001088     |
| 20                                                                                                                                 | Ca      |           |          | 0.0004297    |
| 22                                                                                                                                 | Ti      |           | 0.000006 |              |
| 24                                                                                                                                 | Cr      | 0.02097   |          |              |
| 25                                                                                                                                 | Mn      | 0.00090   |          |              |
| 26                                                                                                                                 | Fe      | 0.01598   | 0.000005 |              |
| 27                                                                                                                                 | Co      | 0.00126   |          |              |
| 28                                                                                                                                 | Ni      | 0.0396    |          |              |
| 42                                                                                                                                 | Mo      | 0.00465   |          |              |
| 74                                                                                                                                 | W       | 0.00013   |          |              |
| Density, atoms/barn-cm                                                                                                             |         | 0.08566   | 0.00142  | 0.005866     |

ratios as the radioisotopes specified in reference 8. The radioisotope source used for the conceptual design is then given by the last column in Table 2. Table 2A shows a comparison between the Feasibility/Trade Studies source and the Conceptual Design source for those radioisotopes having an activity "greater than 100 Ci."

### 3. Gamma Radiation Source

The gamma radiation source (photon intensity as a function of photon energy/group) is automatically produced in the MicroShield-4.10 point-kernel radiation and shielding code once the radioisotope constituents are specified (Reference 9).

#### 3.1 MicroShield-4.10 Source

The results of the last column in Table 2 are input into the MicroShield-4.10 code and the multi-group (maximum of 25 groups) gamma radiation energy source spectrum is produced. Figure 5 shows the gamma radiation source from the MicroShield-4.10 code. It should be noted that most of the radiation is grouped into the energy range with average energy of 0.6616 MeV due primarily to the  $^{137}\text{Cs}/^{137\text{m}}\text{Ba}$  gamma ( $^{137\text{m}}\text{Ba}$   $\gamma$  of 0.6617 MeV).

### 4. Beta Radiation Source

The beta source is derived from the same radioisotope breakdown of Table 2. However, only those radioisotopes that are significant beta emitters are considered for the beta source. These include  $^{90}\text{Sr}$ ,  $^{90}\text{Y}$ ,  $^{137}\text{Cs}$  and  $^{99}\text{Tc}$  (no  $^{99}\text{Tc}$  is specified for the N-Fuel in either reference 7 or 8).

#### 4.1 Beta Spectra from Radioisotopes

A spreadsheet has been developed that groups the beta particle energies into reasonable energy groups and adds the contributions from the significant radioisotopes. Table 3 gives the individual breakdown of the beta energy spectra and the combined beta spectra that can be input to the MCNP-4A code for bremsstrahlung radiation evaluation.

TABLE 2: SSF DETAILED N-FUEL RADIOISOTOPE CONSTITUENTS (Ref. 8, TABLE 2.2)

| Total Other Radioisotopes (Ci) |          |          |                |            |                   |            |
|--------------------------------|----------|----------|----------------|------------|-------------------|------------|
| Scaling Factor                 |          |          |                |            |                   |            |
|                                |          |          | 3283           |            | CONCEPT A MAX.    |            |
|                                |          |          | 0.0105395583   |            | MCO 10 Canisters/ |            |
|                                |          |          | Other "<100Ci" |            | >100Ci            |            |
| ISOTOPE                        | Curies   | Curies   | Curies         | Curies/MCO | Curies/MCO        | TOTAL/MCO  |
| H-3                            | 4.15E+04 | 4.15E+04 |                | 4.3739E+02 |                   | 4.3739E+02 |
| C-14                           | 3.12E+02 | 3.12E+02 |                | 3.2883E+00 |                   | 3.2883E+00 |
| Fe-55                          | 4.36E+03 | 4.36E+03 |                | 4.5952E+01 |                   | 4.5952E+01 |
| Co-60                          | 1.48E+05 |          | 1.48E+05       |            | 786               | 7.8600E+02 |
| Ni-63                          | 4.41E+03 | 4.41E+03 |                | 4.6479E+01 |                   | 4.6479E+01 |
| Se-79                          | 8.13E+01 | 8.13E+01 |                | 8.5687E-01 |                   | 8.5687E-01 |
| * Kr-85                        |          |          |                |            |                   |            |
| Sr-90                          | 1.05E+07 |          | 1.05E+07       |            | 2440              | 2.4400E+03 |
| Y-90                           | 1.05E+07 |          | 1.05E+07       |            | 27941             | 2.7941E+04 |
| Zr-93                          | 3.81E+02 | 3.81E+02 |                | 4.0156E+00 | 27941             | 2.7941E+04 |
| Nb-93m                         | 2.11E+02 | 2.11E+02 |                | 2.2238E+00 |                   | 4.0156E+00 |
| Tc-99                          | 2.72E+03 | 2.72E+03 |                | 2.8668E+01 |                   | 2.2238E+00 |
| Ru-106                         | 1.74E+04 | 1.74E+04 |                | 1.8339E+02 |                   | 2.8668E+01 |
| Rh-106                         | 1.74E+04 | 1.74E+04 |                | 1.8339E+02 |                   | 1.8339E+02 |
| Sn-126                         | 1.42E+02 | 1.42E+02 |                | 1.4966E+00 |                   | 1.8339E+02 |
| Sb-125                         | 7.17E+04 | 7.17E+04 |                | 7.5569E+02 |                   | 1.4966E+00 |
| Te-125m                        | 1.74E+04 | 1.74E+04 |                | 1.8339E+02 |                   | 7.5569E+02 |
| I-129                          | 5.93E+00 | 5.93E+00 |                | 6.2500E-02 |                   | 1.8339E+02 |
| Cs-134                         | 4.63E+04 | 4.63E+04 |                | 4.8798E+02 |                   | 6.2500E-02 |
| Cs-135                         | 7.25E+01 | 7.25E+01 |                | 7.6412E-01 |                   | 4.8798E+02 |
| Cs-137                         | 1.35E+07 |          | 1.35E+07       |            |                   | 7.6412E-01 |
| Ba-137m                        | 1.28E+07 |          | 1.28E+07       |            | 37929             | 3.7929E+04 |
| Ce-144                         | 1.80E+04 | 1.80E+04 |                | 1.8971E+02 | 35906             | 3.5906E+04 |
| Pr-144                         | 1.78E+04 | 1.78E+04 |                | 1.8760E+02 |                   | 1.8971E+02 |
| Pm-147                         | 1.08E+06 |          | 1.08E+06       |            |                   | 1.8760E+02 |
| Sm-151                         | 1.72E+05 |          | 1.72E+05       |            | 8180              | 8.1800E+03 |
| Eu-152                         | 1.02E+03 | 1.02E+03 |                | 1.0750E+01 | 344               | 3.4400E+02 |
| Eu-154                         | 1.28E+05 |          | 1.28E+05       |            |                   | 1.0750E+01 |
| Eu-155                         | 3.31E+04 | 3.31E+04 |                | 3.4886E+02 | 804               | 8.0400E+02 |
| U-234                          | 8.38E+02 | 8.38E+02 |                | 8.8321E+00 |                   | 3.4886E+02 |
| U-235                          | 3.20E+01 | 3.20E+01 |                | 3.3727E-01 |                   | 8.8321E+00 |
| U-236                          | 1.25E+02 | 1.25E+02 |                | 1.3174E+00 |                   | 3.3727E-01 |
| U-238                          | 6.68E+02 | 6.68E+02 |                | 7.0404E+00 |                   | 1.3174E+00 |
| Np-237                         | 6.54E+01 | 6.54E+01 |                | 6.8929E-01 |                   | 7.0404E+00 |
| Pu-238                         | 1.25E+05 |          | 1.25E+05       |            |                   | 6.8929E-01 |
| Pu-239                         | 2.25E+05 |          | 2.25E+05       |            | 496               | 4.9600E+02 |
| Pu-240                         | 1.30E+05 |          | 1.30E+05       |            | 499               | 4.9900E+02 |
| Pu-241                         | 7.38E+06 |          | 7.38E+06       |            | 378               | 3.7800E+02 |
| Pu-242                         | 5.90E+01 | 5.90E+01 |                | 6.2183E-01 | 35021             | 3.5021E+04 |
| Am-241                         | 3.15E+05 |          | 3.15E+05       |            |                   | 6.2183E-01 |
| Cm-242                         | 2.90E+02 | 2.90E+02 |                | 3.0565E+00 | 742               | 7.4200E+02 |
| Cm-244                         | 1.51E+04 | 1.51E+04 |                | 1.5915E+02 |                   | 3.0565E+00 |
| Total                          | 5.73E+07 | 3.11E+05 | 5.70E+07       | 3.2830E+03 | 1.79E+05          | 1.8269E+05 |
|                                | 5.73E+07 |          |                | 3283       | 179407            | 182690     |

\* Note: Kr-85 was not included in Table 2.2, but is included in Concept A

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TABLE 2A: COMPARISON OF FEASIBILITY/TRADE STUDY MCO RADIONUCLIDE  
 INVENTORY WITH THAT OF THE CONCPETUAL DESIGN MCO SPECIFICATION

| Radionuclide<br>> 100 Ci | Feasibility<br>LIMIT (Ci)<br>Note 1 | Conceptual Design<br>A MAX (Ci)<br>Note 2 |
|--------------------------|-------------------------------------|-------------------------------------------|
| -----                    | -----                               | -----                                     |
| Co-60                    | 23 (622)                            | 786                                       |
| Kr-85                    | 1730                                | 2440                                      |
| Sr-90                    | 19800                               | 27941                                     |
| Y-90                     | 19800                               | 27941                                     |
| Cs-137                   | 26400                               | 37929                                     |
| Ba-137m                  | 25000                               | 35906                                     |
| Pm-147                   | 6030                                | 8180                                      |
| Sm-151                   | 260                                 | 344                                       |
| Eu-154                   | 483 added                           | 804                                       |
| Pu-238                   | 300                                 | 496                                       |
| Pu-239                   | 365                                 | 499                                       |
| Pu-240                   | 263                                 | 378                                       |
| Pu-241                   | 22000                               | 35021                                     |
| Am-241                   | 465                                 | 742                                       |
| All other                | 1482                                | 3283                                      |
| -----                    | -----                               | -----                                     |
| TOTAL                    | 125000 Ci/MCO                       | 182690 Ci/MCO                             |

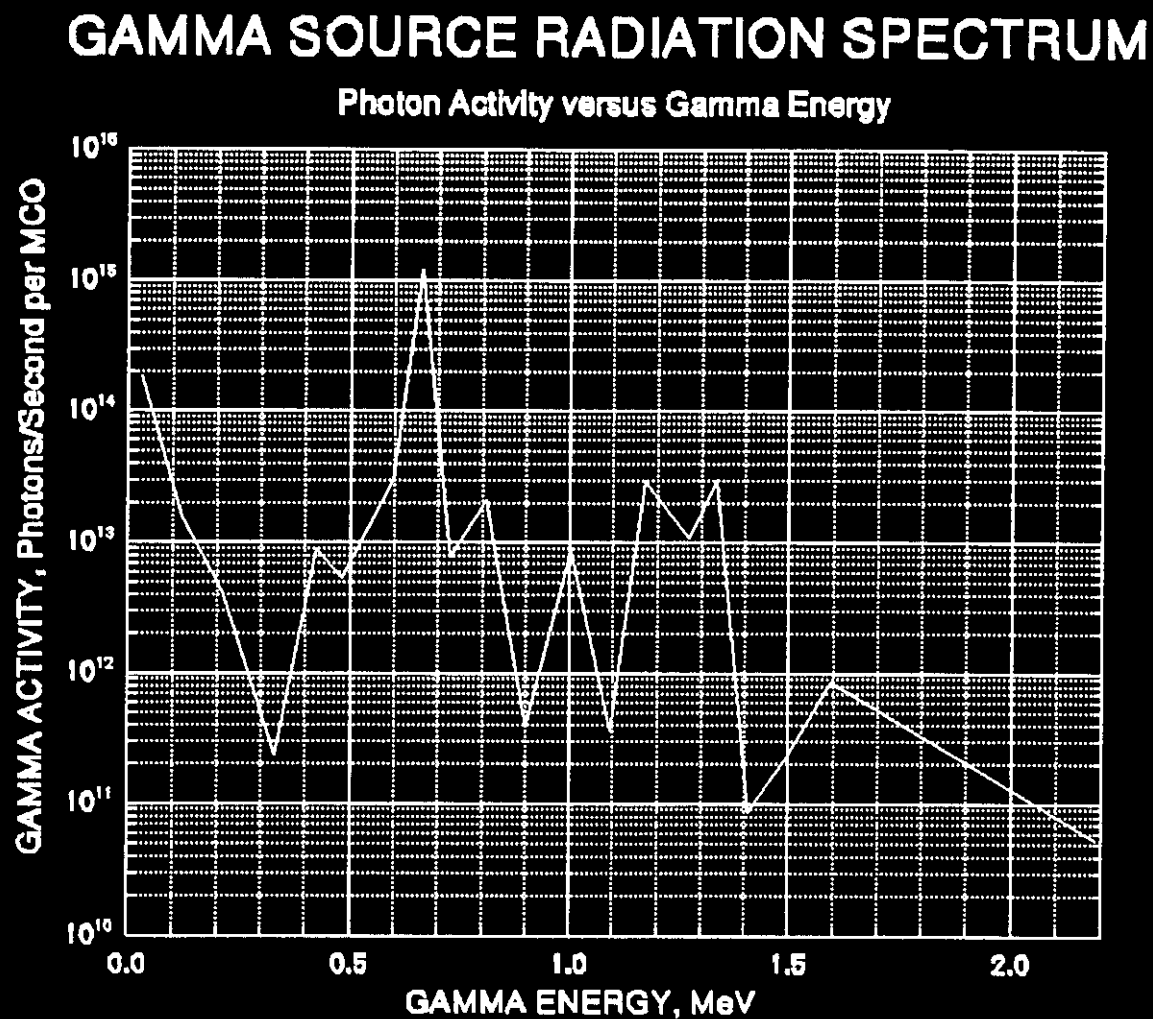
Note 1: Mark IV 16% <sup>240</sup>Pu @ 10 years (622 Ci used for Co-60)

Note 2: From Table 3.2.2.1.2.2-1 of Performance Specifications

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FIGURE 5: MS4.10 MCO GAMMA RADIATION SOURCE SPECTRUM



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TABLE 3:  
MCO: CONCEPT A MAX MCO 10 CANISTERS

| Isotope | Max<br>Energy | "MCO" (1)<br>Curies/MCO | Problty<br>/Decay | "MCO" Betas<br>Betas/sec/MCO |
|---------|---------------|-------------------------|-------------------|------------------------------|
| Y-90    | 2.284E+00     | 2.794E+04               | 0.999890          | 1.034E+15                    |
| Sr-90   | 5.460E-01     | 2.794E+04               | 1.000000          | 1.034E+15                    |
| Tc-99   | 2.936E-01     | 2.867E+01               | 0.999990          | 1.061E+12                    |
| Cs-137  | 5.116E-01     | 3.793E+04               | 0.946000          | 1.328E+15                    |

| Y-90<br>=====           |              |             |          |          |                     |                     |
|-------------------------|--------------|-------------|----------|----------|---------------------|---------------------|
| Bin-<br>Energy<br>(MeV) | Dist<br>func | Avg<br>Dist | Area     | Fraction | Avg Energy<br>(MeV) | Beta/sec<br>per MCO |
| 0.0000                  | 0.3250       |             |          |          |                     |                     |
| 0.1500                  | 0.4400       | 0.3825      | 0.057375 | 0.058553 | 0.075               | 6.053E+13           |
| 0.3000                  | 0.5200       | 0.4800      | 0.072000 | 0.073479 | 0.225               | 7.596E+13           |
| 0.4500                  | 0.5800       | 0.5500      | 0.082500 | 0.084194 | 0.375               | 8.703E+13           |
| 0.6000                  | 0.6150       | 0.5975      | 0.089625 | 0.091466 | 0.525               | 9.455E+13           |
| 0.7500                  | 0.6250       | 0.6200      | 0.093000 | 0.094910 | 0.675               | 9.811E+13           |
| 0.9000                  | 0.6250       | 0.6250      | 0.093750 | 0.095675 | 0.825               | 9.890E+13           |
| 1.0500                  | 0.6150       | 0.6200      | 0.093000 | 0.094910 | 0.975               | 9.811E+13           |
| 1.2000                  | 0.5800       | 0.5975      | 0.089625 | 0.091466 | 1.125               | 9.455E+13           |
| 1.3500                  | 0.5250       | 0.5525      | 0.082875 | 0.084577 | 1.275               | 8.743E+13           |
| 1.5000                  | 0.4550       | 0.4900      | 0.073500 | 0.075010 | 1.425               | 7.754E+13           |
| 1.6500                  | 0.3650       | 0.4100      | 0.061500 | 0.062763 | 1.575               | 6.488E+13           |
| 1.8000                  | 0.2500       | 0.3075      | 0.046125 | 0.047072 | 1.725               | 4.866E+13           |
| 1.9500                  | 0.1300       | 0.1900      | 0.028500 | 0.029085 | 1.875               | 3.007E+13           |
| 2.1000                  | 0.0450       | 0.0875      | 0.013125 | 0.013395 | 2.025               | 1.385E+13           |
| 2.2450                  | 0.0000       | 0.0225      | 0.003375 | 0.003444 | 2.1725              | 3.560E+12           |
| Totals:                 | 6.695000     | 6.532500    | 0.979875 | 1.000000 |                     | 1.034E+15           |

| Sr-90<br>=====          |              |             |          |          |                     |                     |
|-------------------------|--------------|-------------|----------|----------|---------------------|---------------------|
| Bin-<br>Energy<br>(MeV) | Dist<br>func | Avg<br>Dist | Area     | Fraction | Avg Energy<br>(MeV) | Beta/sec<br>per MCO |
| 0.0000                  | 2.6500       |             |          |          |                     |                     |
| 0.1500                  | 2.6500       | 2.6500      | 0.397500 | 0.391144 | 0.075               | 4.044E+14           |
| 0.3000                  | 2.1500       | 2.4000      | 0.360000 | 0.354244 | 0.225               | 3.662E+14           |
| 0.4500                  | 0.6500       | 1.4000      | 0.210000 | 0.206642 | 0.375               | 2.136E+14           |
| 0.6000                  | 0.0000       | 0.3250      | 0.048750 | 0.047970 | 0.525               | 4.959E+13           |
| Totals:                 | 8.100000     | 6.775000    | 1.016250 | 1.000000 |                     | 1.034E+15           |

TABLE 3: (Continued)

| Tc-99                   |              |             |          |          |                     |                     |
|-------------------------|--------------|-------------|----------|----------|---------------------|---------------------|
| Bin-<br>Energy<br>(MeV) | Dist<br>func | Avg<br>Dist | Area     | Fraction | Avg Energy<br>(MeV) | Beta/sec<br>per MCO |
| 0.0000                  | 7.8000       |             |          |          |                     |                     |
| 0.1500                  | 3.1000       | 5.4500      | 0.817500 | 0.778571 | 0.075               | 8.258E+11           |
| 0.3000                  | 0.0000       | 1.5500      | 0.232500 | 0.221429 | 0.225               | 2.349E+11           |
|                         | -----        | -----       | -----    | -----    |                     | -----               |
| Totals:                 | 10.900000    | 7.000000    | 1.050000 | 1.000000 |                     | 1.061E+12           |

| Cs-137                  |              |             |          |          |                     |                     |
|-------------------------|--------------|-------------|----------|----------|---------------------|---------------------|
| Bin-<br>Energy<br>(MeV) | Dist<br>func | Avg<br>Dist | Area     | Fraction | Avg Energy<br>(MeV) | Beta/sec<br>per MCO |
| 0.0000                  | 2.8500       |             |          |          |                     |                     |
| 0.1500                  | 2.6500       | 2.7500      | 0.412500 | 0.424710 | 0.075               | 5.638E+14           |
| 0.3000                  | 2.0000       | 2.3250      | 0.348750 | 0.359073 | 0.225               | 4.767E+14           |
| 0.4500                  | 0.4000       | 1.2000      | 0.180000 | 0.185328 | 0.375               | 2.460E+14           |
| 0.6000                  | 0.0000       | 0.2000      | 0.030000 | 0.030888 | 0.525               | 4.101E+13           |
|                         | -----        | -----       | -----    | -----    |                     | -----               |
| Totals:                 | 7.900000     | 6.475000    | 0.971250 | 1.000000 |                     | 1.328E+15           |

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# CONCEPT A Max MCO

10 N-Fuel Canisters(2x5 High) @ 7 Fuel Rods

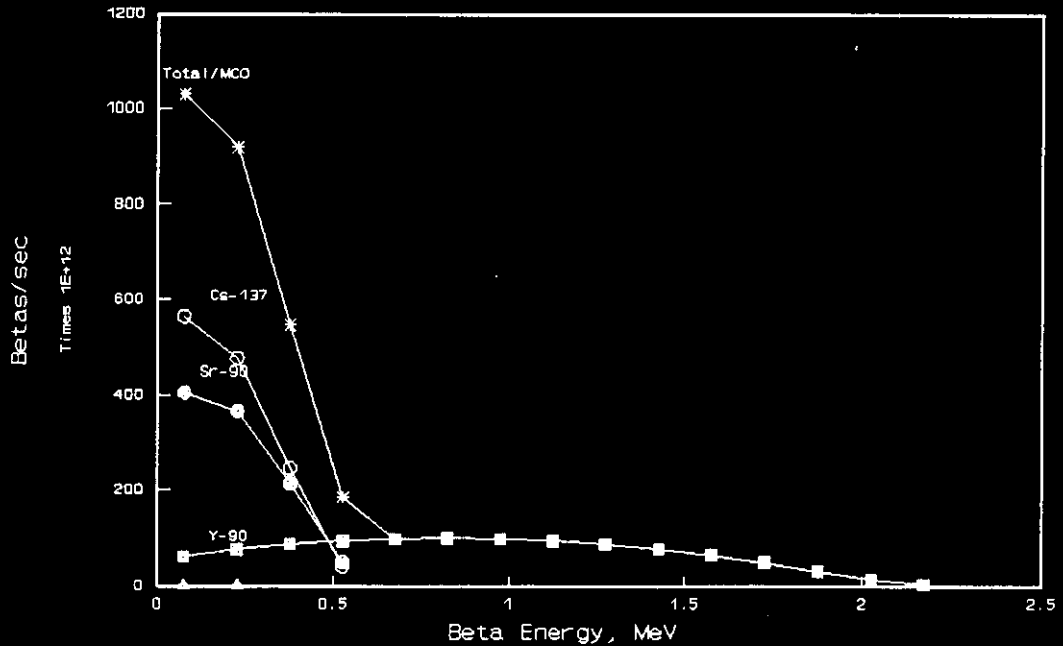


TABLE 3 (Continued): TABLE 3 SUMMARY FIGURE

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## 5. Beta-Induced Bremsstrahlung Radiation

There are two methods of calculating beta-induced bremsstrahlung radiation: 1) by using the beta spectra of Table 3 in the MCNP-4A code or 2) by using the ISO-PC point kernel radiation analysis code (Reference 10). The ISO-PC code is based on the original version of ISOSHLI II (Reference 11) which has the ability to calculate bremsstrahlung radiation from beta-emitting radioisotopes input to the code.

### 5.1 Comparison of MCNP-4A and ISO-PC Bremsstrahlung Results

Although MCNP-4A is a sophisticated monte carlo radiation transport code, it takes a significant amount of computer time to obtain reasonably accurate/precise answers due to the "statistical" nature of the particle tracking calculations (typical times for runs on a 486-PC is in excess of 100 hours for bremsstrahlung radiation analysis). On the other hand, ISO-PC is an extremely fast running program (typical times on the order of 1 minute). For the purposes of simple geometry, conceptual design analyses, it is therefore significantly more efficient to use the ISO-PC code.

A check can be made to assess the general accuracy of the ISO-PC code compared to the "presumably" more accurate MCNP-4A code. The following bremsstrahlung results are obtained for the two programs for the MCO source configuration at a distance of 2 inches from the MCO mid-height surface showing that bremsstrahlung is only about 3% of the gamma radiation contribution to the dose rate:

| Radiation Source                           | MCNP-4A    | ISO-PC     |
|--------------------------------------------|------------|------------|
| <sup>90</sup> Sr - Beta<br>Bremsstrahlung  |            | 0.066 R/h  |
| <sup>90</sup> Y - Beta<br>Bremsstrahlung   |            | 36.67 R/h  |
| <sup>137</sup> Cs - Beta<br>Bremsstrahlung |            | 0.269 R/h  |
| TOTAL BREMSSTRAHLUNG                       | 17.594 R/h | 37.005 R/h |
| Gamma Radiation                            | 497.5 R/h  | 1348 R/h * |
| Ratio of Brem/Gamma                        | 3.54 %     | 2.75 %     |

\* Note: <sup>137m</sup>Ba - Gamma Radiation Only

## 6. Neutron Radiation Source

A potentially key radiation source is the neutron source. In most radioactive waste shielding applications, neutrons are of little concern. There are usually two reasons for being able to ignore the neutron contribution: 1) the radioactive waste has been processed with most of the uranium and transuranic elements removed from the waste and 2) concrete is usually used for shielding the high-intensity gamma radiation and this concrete will also attenuate any small neutron source associated with the waste.

The CSB/SNF conceptual design must consider the neutron source because 1) there is significant uranium and transuranic elements in the spent nuclear fuel leading to spontaneous fission and the potential for ( $\alpha$ ,n) reactions, and 2) the MCO containing the SNF canisters is transported in a steel shielded transfer cask from the K-basins areas to the CSB/SSF building. Consideration of adding an efficient neutron shield to the transfer cask shielding must at least be evaluated and assessed.

### 6.1 SOURCES Code Neutron Spectra

The SOURCES computer code can be used to obtain a neutron source spectrum for the MCO based on the fuel and other material constituents within the MCO (Reference 12). The starting point for the input to the SOURCES code is the radioisotopic inventory from Table 2.

#### 6.1.1 150 Group Table and Plot

Based on the execution of the SOURCES code, a 150 energy group neutron source is obtained. This neutron source is based on both spontaneous fission and ( $\alpha$ ,n) reaction within the MCO. As can be seen from Table 4 and Figure 6, the ( $\alpha$ ,n) reaction contributes a very small amount to the total neutron spectrum and could be ignored within the accuracy of the source analysis.

### 6.2 ORIGEN2 Code Neutron Source

In order to check the SOURCES code calculation, a total neutron source (n/sec from the MCO can be calculated using the ORIGEN2.1 code (Reference 13). The cross section libraries used in the ORIGEN2.1 analyses (421, 422, 423, 441, 442, and 443) are provided by the Reactor Physics group of WHC based on key reactor radionuclides. The MCO total neutron source (neutrons per second) obtained from the ORIGEN2.1 code should agree reasonably with the total n/sec obtained from Table 4 based on the SOURCES code analysis.

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TABLE 4:  
MCO Neutron Source Spectra

| Volume (cc) = 1314337 cm <sup>3</sup> |       |       |           |           |           |           |           |           |         |
|---------------------------------------|-------|-------|-----------|-----------|-----------|-----------|-----------|-----------|---------|
| GRP                                   | HI    | LOW   | Spon.     | Fiss      | Alpha-n   | Total     | Spon.     | Fiss      | Alpha-n |
| NO.                                   | MeV   | MeV   | n/sec/cc  | n/sec/cc  | n/sec/cc  | n/sec/cc  | n/sec     | n/sec     | n/sec   |
| -----                                 | ----- | ----- | -----     | -----     | -----     | -----     | -----     | -----     | -----   |
| 1                                     | 0.1   | 0.0   | 2.114E-01 | 5.162E-05 | 2.115E-01 | 2.779E+05 | 6.785E+01 | 2.779E+05 |         |
| 2                                     | 0.2   | 0.1   | 3.688E-01 | 1.124E-04 | 3.689E-01 | 4.847E+05 | 1.477E+02 | 4.849E+05 |         |
| 3                                     | 0.3   | 0.2   | 4.538E-01 | 3.163E-04 | 4.541E-01 | 5.964E+05 | 4.157E+02 | 5.969E+05 |         |
| 4                                     | 0.4   | 0.3   | 5.097E-01 | 1.687E-03 | 5.114E-01 | 6.699E+05 | 2.217E+03 | 6.721E+05 |         |
| 5                                     | 0.5   | 0.4   | 5.477E-01 | 3.485E-03 | 5.512E-01 | 7.199E+05 | 4.580E+03 | 7.244E+05 |         |
| 6                                     | 0.6   | 0.5   | 5.729E-01 | 4.817E-03 | 5.777E-01 | 7.530E+05 | 6.331E+03 | 7.593E+05 |         |
| 7                                     | 0.7   | 0.6   | 5.885E-01 | 5.869E-03 | 5.944E-01 | 7.735E+05 | 7.714E+03 | 7.812E+05 |         |
| 8                                     | 0.8   | 0.7   | 5.967E-01 | 6.731E-03 | 6.034E-01 | 7.843E+05 | 8.847E+03 | 7.931E+05 |         |
| 9                                     | 0.9   | 0.8   | 5.989E-01 | 7.238E-03 | 6.061E-01 | 7.872E+05 | 9.513E+03 | 7.967E+05 |         |
| 10                                    | 1.0   | 0.9   | 5.964E-01 | 7.443E-03 | 6.038E-01 | 7.839E+05 | 9.783E+03 | 7.937E+05 |         |
| 11                                    | 1.1   | 1.0   | 5.901E-01 | 7.458E-03 | 5.976E-01 | 7.756E+05 | 9.802E+03 | 7.854E+05 |         |
| 12                                    | 1.2   | 1.1   | 5.806E-01 | 7.419E-03 | 5.880E-01 | 7.631E+05 | 9.751E+03 | 7.729E+05 |         |
| 13                                    | 1.3   | 1.2   | 5.687E-01 | 7.243E-03 | 5.759E-01 | 7.475E+05 | 9.520E+03 | 7.570E+05 |         |
| 14                                    | 1.4   | 1.3   | 5.548E-01 | 6.787E-03 | 5.616E-01 | 7.292E+05 | 8.920E+03 | 7.381E+05 |         |
| 15                                    | 1.5   | 1.4   | 5.394E-01 | 6.102E-03 | 5.455E-01 | 7.090E+05 | 8.020E+03 | 7.170E+05 |         |
| 16                                    | 1.6   | 1.5   | 5.227E-01 | 5.355E-03 | 5.281E-01 | 6.870E+05 | 7.038E+03 | 6.940E+05 |         |
| 17                                    | 1.7   | 1.6   | 5.052E-01 | 4.704E-03 | 5.099E-01 | 6.640E+05 | 6.183E+03 | 6.702E+05 |         |
| 18                                    | 1.8   | 1.7   | 4.870E-01 | 5.254E-03 | 4.923E-01 | 6.401E+05 | 6.906E+03 | 6.470E+05 |         |
| 19                                    | 1.9   | 1.8   | 4.684E-01 | 6.981E-03 | 4.754E-01 | 6.156E+05 | 9.175E+03 | 6.248E+05 |         |
| 20                                    | 2.0   | 1.9   | 4.497E-01 | 7.534E-03 | 4.572E-01 | 5.911E+05 | 9.902E+03 | 6.010E+05 |         |
| 21                                    | 2.1   | 2.0   | 4.308E-01 | 8.011E-03 | 4.388E-01 | 5.662E+05 | 1.053E+04 | 5.767E+05 |         |
| 22                                    | 2.2   | 2.1   | 4.120E-01 | 8.764E-03 | 4.208E-01 | 5.415E+05 | 1.152E+04 | 5.530E+05 |         |
| 23                                    | 2.3   | 2.2   | 3.934E-01 | 9.132E-03 | 4.025E-01 | 5.171E+05 | 1.200E+04 | 5.291E+05 |         |
| 24                                    | 2.4   | 2.3   | 3.751E-01 | 9.427E-03 | 3.845E-01 | 4.930E+05 | 1.239E+04 | 5.054E+05 |         |
| 25                                    | 2.5   | 2.4   | 3.571E-01 | 9.851E-03 | 3.670E-01 | 4.693E+05 | 1.295E+04 | 4.823E+05 |         |
| 26                                    | 2.6   | 2.5   | 3.396E-01 | 1.050E-02 | 3.501E-01 | 4.463E+05 | 1.380E+04 | 4.601E+05 |         |
| 27                                    | 2.7   | 2.6   | 3.225E-01 | 1.201E-02 | 3.345E-01 | 4.239E+05 | 1.579E+04 | 4.397E+05 |         |
| 28                                    | 2.8   | 2.7   | 3.059E-01 | 1.421E-02 | 3.201E-01 | 4.021E+05 | 1.868E+04 | 4.207E+05 |         |
| 29                                    | 2.9   | 2.8   | 2.899E-01 | 1.658E-02 | 3.065E-01 | 3.810E+05 | 2.179E+04 | 4.028E+05 |         |
| 30                                    | 3.0   | 2.9   | 2.744E-01 | 1.875E-02 | 2.932E-01 | 3.607E+05 | 2.464E+04 | 3.853E+05 |         |
| 31                                    | 3.1   | 3.0   | 2.595E-01 | 2.065E-02 | 2.802E-01 | 3.411E+05 | 2.714E+04 | 3.682E+05 |         |
| 32                                    | 3.2   | 3.1   | 2.452E-01 | 2.197E-02 | 2.672E-01 | 3.223E+05 | 2.888E+04 | 3.512E+05 |         |
| 33                                    | 3.3   | 3.2   | 2.314E-01 | 2.271E-02 | 2.541E-01 | 3.041E+05 | 2.985E+04 | 3.340E+05 |         |
| 34                                    | 3.4   | 3.3   | 2.183E-01 | 2.253E-02 | 2.408E-01 | 2.869E+05 | 2.961E+04 | 3.165E+05 |         |
| 35                                    | 3.5   | 3.4   | 2.057E-01 | 2.217E-02 | 2.279E-01 | 2.704E+05 | 2.914E+04 | 2.995E+05 |         |
| 36                                    | 3.6   | 3.5   | 1.937E-01 | 2.183E-02 | 2.155E-01 | 2.546E+05 | 2.869E+04 | 2.833E+05 |         |
| 37                                    | 3.7   | 3.6   | 1.823E-01 | 2.144E-02 | 2.037E-01 | 2.396E+05 | 2.818E+04 | 2.678E+05 |         |
| 38                                    | 3.8   | 3.7   | 1.714E-01 | 2.093E-02 | 1.923E-01 | 2.253E+05 | 2.751E+04 | 2.528E+05 |         |
| 39                                    | 3.9   | 3.8   | 1.611E-01 | 2.035E-02 | 1.815E-01 | 2.117E+05 | 2.675E+04 | 2.385E+05 |         |
| 40                                    | 4.0   | 3.9   | 1.513E-01 | 1.985E-02 | 1.712E-01 | 1.989E+05 | 2.609E+04 | 2.249E+05 |         |
| 41                                    | 4.1   | 4.0   | 1.420E-01 | 1.945E-02 | 1.615E-01 | 1.866E+05 | 2.556E+04 | 2.122E+05 |         |
| 42                                    | 4.2   | 4.1   | 1.332E-01 | 1.913E-02 | 1.523E-01 | 1.751E+05 | 2.514E+04 | 2.002E+05 |         |
| 43                                    | 4.3   | 4.2   | 1.249E-01 | 1.882E-02 | 1.437E-01 | 1.642E+05 | 2.474E+04 | 1.889E+05 |         |
| 44                                    | 4.4   | 4.3   | 1.170E-01 | 1.850E-02 | 1.355E-01 | 1.538E+05 | 2.432E+04 | 1.781E+05 |         |
| 45                                    | 4.5   | 4.4   | 1.096E-01 | 1.818E-02 | 1.278E-01 | 1.441E+05 | 2.389E+04 | 1.679E+05 |         |
| 46                                    | 4.6   | 4.5   | 1.025E-01 | 1.784E-02 | 1.203E-01 | 1.347E+05 | 2.345E+04 | 1.582E+05 |         |
| 47                                    | 4.7   | 4.6   | 9.593E-02 | 1.748E-02 | 1.134E-01 | 1.261E+05 | 2.297E+04 | 1.491E+05 |         |
| 48                                    | 4.8   | 4.7   | 8.970E-02 | 1.708E-02 | 1.068E-01 | 1.179E+05 | 2.245E+04 | 1.403E+05 |         |
| 49                                    | 4.9   | 4.8   | 8.384E-02 | 1.666E-02 | 1.005E-01 | 1.102E+05 | 2.190E+04 | 1.321E+05 |         |
| 50                                    | 5.0   | 4.9   | 7.832E-02 | 1.616E-02 | 9.448E-02 | 1.029E+05 | 2.124E+04 | 1.242E+05 |         |
| 51                                    | 5.1   | 5.0   | 7.314E-02 | 1.499E-02 | 8.813E-02 | 9.613E+04 | 1.970E+04 | 1.158E+05 |         |
| 52                                    | 5.2   | 5.1   | 6.827E-02 | 1.384E-02 | 8.211E-02 | 8.973E+04 | 1.819E+04 | 1.079E+05 |         |
| 53                                    | 5.3   | 5.2   | 6.370E-02 | 1.285E-02 | 7.655E-02 | 8.372E+04 | 1.689E+04 | 1.006E+05 |         |
| 54                                    | 5.4   | 5.3   | 5.941E-02 | 1.177E-02 | 7.118E-02 | 7.808E+04 | 1.547E+04 | 9.355E+04 |         |
| 55                                    | 5.5   | 5.4   | 5.539E-02 | 1.086E-02 | 6.625E-02 | 7.280E+04 | 1.427E+04 | 8.707E+04 |         |
| 56                                    | 5.6   | 5.5   | 5.162E-02 | 1.046E-02 | 6.208E-02 | 6.785E+04 | 1.375E+04 | 8.159E+04 |         |

✓ 21-B

TABLE 4:  
MCO Neutron Source Spectra  
(Continued)

| Volume (cc) = 1314337 cm <sup>3</sup> |       |       |           |           |           |           |           |           |           |
|---------------------------------------|-------|-------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| GRP HI                                | LOW   | Spon. | Fiss      | Alpha-n   | Total     | Spon.     | Fiss      | Alpha-n   | Total-MCO |
| NO.                                   | MeV   | MeV   | n/sec/cc  | n/sec/cc  | n/sec/cc  | n/sec     | n/sec     | n/sec     | n/sec     |
| -----                                 | ----- | ----- | -----     | -----     | -----     | -----     | -----     | -----     | -----     |
| 57                                    | 5.7   | 5.6   | 4.809E-02 | 1.047E-02 | 5.856E-02 | 6.321E+04 | 1.376E+04 | 7.697E+04 |           |
| 58                                    | 5.8   | 5.7   | 4.479E-02 | 1.049E-02 | 5.528E-02 | 5.887E+04 | 1.379E+04 | 7.266E+04 |           |
| 59                                    | 5.9   | 5.8   | 4.170E-02 | 1.025E-02 | 5.195E-02 | 5.481E+04 | 1.347E+04 | 6.828E+04 |           |
| 60                                    | 6.0   | 5.9   | 3.880E-02 | 9.733E-03 | 4.853E-02 | 5.100E+04 | 1.279E+04 | 6.379E+04 |           |
| 61                                    | 6.1   | 6.0   | 3.610E-02 | 8.958E-03 | 4.506E-02 | 4.745E+04 | 1.177E+04 | 5.922E+04 |           |
| 62                                    | 6.2   | 6.1   | 3.358E-02 | 8.853E-03 | 4.243E-02 | 4.414E+04 | 1.164E+04 | 5.577E+04 |           |
| 63                                    | 6.3   | 6.2   | 3.122E-02 | 9.072E-03 | 4.029E-02 | 4.103E+04 | 1.192E+04 | 5.296E+04 |           |
| 64                                    | 6.4   | 6.3   | 2.902E-02 | 9.295E-03 | 3.832E-02 | 3.814E+04 | 1.222E+04 | 5.036E+04 |           |
| 65                                    | 6.5   | 6.4   | 2.696E-02 | 9.773E-03 | 3.673E-02 | 3.543E+04 | 1.285E+04 | 4.828E+04 |           |
| 66                                    | 6.6   | 6.5   | 2.505E-02 | 1.021E-02 | 3.526E-02 | 3.292E+04 | 1.342E+04 | 4.634E+04 |           |
| 67                                    | 6.7   | 6.6   | 2.326E-02 | 1.057E-02 | 3.383E-02 | 3.057E+04 | 1.389E+04 | 4.446E+04 |           |
| 68                                    | 6.8   | 6.7   | 2.160E-02 | 1.080E-02 | 3.240E-02 | 2.839E+04 | 1.419E+04 | 4.258E+04 |           |
| 69                                    | 6.9   | 6.8   | 2.005E-02 | 1.086E-02 | 3.091E-02 | 2.635E+04 | 1.427E+04 | 4.063E+04 |           |
| 70                                    | 7.0   | 6.9   | 1.860E-02 | 1.086E-02 | 2.946E-02 | 2.445E+04 | 1.427E+04 | 3.872E+04 |           |
| 71                                    | 7.1   | 7.0   | 1.726E-02 | 1.086E-02 | 2.812E-02 | 2.269E+04 | 1.427E+04 | 3.696E+04 |           |
| 72                                    | 7.2   | 7.1   | 1.601E-02 | 1.085E-02 | 2.686E-02 | 2.104E+04 | 1.426E+04 | 3.530E+04 |           |
| 73                                    | 7.3   | 7.2   | 1.484E-02 | 1.085E-02 | 2.569E-02 | 1.950E+04 | 1.426E+04 | 3.377E+04 |           |
| 74                                    | 7.4   | 7.3   | 1.376E-02 | 1.083E-02 | 2.459E-02 | 1.809E+04 | 1.423E+04 | 3.232E+04 |           |
| 75                                    | 7.5   | 7.4   | 1.275E-02 | 1.080E-02 | 2.355E-02 | 1.676E+04 | 1.419E+04 | 3.095E+04 |           |
| 76                                    | 7.6   | 7.5   | 1.182E-02 | 1.071E-02 | 2.253E-02 | 1.554E+04 | 1.408E+04 | 2.961E+04 |           |
| 77                                    | 7.7   | 7.6   | 1.095E-02 | 1.054E-02 | 2.149E-02 | 1.439E+04 | 1.385E+04 | 2.825E+04 |           |
| 78                                    | 7.8   | 7.7   | 1.014E-02 | 1.031E-02 | 2.045E-02 | 1.333E+04 | 1.355E+04 | 2.688E+04 |           |
| 79                                    | 7.9   | 7.8   | 9.387E-03 | 1.005E-02 | 1.944E-02 | 1.234E+04 | 1.321E+04 | 2.555E+04 |           |
| 80                                    | 8.0   | 7.9   | 8.690E-03 | 9.733E-03 | 1.842E-02 | 1.142E+04 | 1.279E+04 | 2.421E+04 |           |
| 81                                    | 8.1   | 8.0   | 8.043E-03 | 9.368E-03 | 1.741E-02 | 1.057E+04 | 1.231E+04 | 2.288E+04 |           |
| 82                                    | 8.2   | 8.1   | 7.444E-03 | 9.026E-03 | 1.647E-02 | 9.784E+03 | 1.186E+04 | 2.165E+04 |           |
| 83                                    | 8.3   | 8.2   | 6.887E-03 | 8.682E-03 | 1.557E-02 | 9.052E+03 | 1.141E+04 | 2.046E+04 |           |
| 84                                    | 8.4   | 8.3   | 6.370E-03 | 8.373E-03 | 1.474E-02 | 8.372E+03 | 1.100E+04 | 1.938E+04 |           |
| 85                                    | 8.5   | 8.4   | 5.892E-03 | 8.149E-03 | 1.404E-02 | 7.744E+03 | 1.071E+04 | 1.845E+04 |           |
| 86                                    | 8.6   | 8.5   | 5.448E-03 | 7.963E-03 | 1.341E-02 | 7.161E+03 | 1.047E+04 | 1.763E+04 |           |
| 87                                    | 8.7   | 8.6   | 5.036E-03 | 7.782E-03 | 1.282E-02 | 6.619E+03 | 1.023E+04 | 1.685E+04 |           |
| 88                                    | 8.8   | 8.7   | 4.656E-03 | 7.637E-03 | 1.229E-02 | 6.120E+03 | 1.004E+04 | 1.616E+04 |           |
| 89                                    | 8.9   | 8.8   | 4.302E-03 | 7.513E-03 | 1.182E-02 | 5.654E+03 | 9.875E+03 | 1.553E+04 |           |
| 90                                    | 9.0   | 8.9   | 3.975E-03 | 7.411E-03 | 1.139E-02 | 5.224E+03 | 9.741E+03 | 1.497E+04 |           |
| 91                                    | 9.1   | 9.0   | 3.673E-03 | 7.286E-03 | 1.096E-02 | 4.828E+03 | 9.576E+03 | 1.440E+04 |           |
| 92                                    | 9.2   | 9.1   | 3.392E-03 | 7.102E-03 | 1.049E-02 | 4.458E+03 | 9.334E+03 | 1.379E+04 |           |
| 93                                    | 9.3   | 9.2   | 3.133E-03 | 6.832E-03 | 9.965E-03 | 4.118E+03 | 8.980E+03 | 1.310E+04 |           |
| 94                                    | 9.4   | 9.3   | 2.892E-03 | 6.435E-03 | 9.327E-03 | 3.801E+03 | 8.458E+03 | 1.226E+04 |           |
| 95                                    | 9.5   | 9.4   | 2.670E-03 | 5.922E-03 | 8.592E-03 | 3.509E+03 | 7.784E+03 | 1.129E+04 |           |
| 96                                    | 9.6   | 9.5   | 2.465E-03 | 5.329E-03 | 7.794E-03 | 3.240E+03 | 7.004E+03 | 1.024E+04 |           |
| 97                                    | 9.7   | 9.6   | 2.275E-03 | 4.642E-03 | 6.917E-03 | 2.990E+03 | 6.101E+03 | 9.091E+03 |           |
| 98                                    | 9.8   | 9.7   | 2.099E-03 | 3.943E-03 | 6.042E-03 | 2.759E+03 | 5.182E+03 | 7.941E+03 |           |
| 99                                    | 9.9   | 9.8   | 1.937E-03 | 3.240E-03 | 5.177E-03 | 2.546E+03 | 4.258E+03 | 6.804E+03 |           |
| 100                                   | 10.0  | 9.9   | 1.787E-03 | 2.537E-03 | 4.324E-03 | 2.349E+03 | 3.334E+03 | 5.683E+03 |           |
| 101                                   | 10.1  | 10.0  | 1.648E-03 | 2.016E-03 | 3.664E-03 | 2.166E+03 | 2.650E+03 | 4.816E+03 |           |
| 102                                   | 10.2  | 10.1  | 1.520E-03 | 1.652E-03 | 3.172E-03 | 1.998E+03 | 2.171E+03 | 4.169E+03 |           |
| 103                                   | 10.3  | 10.2  | 1.401E-03 | 1.349E-03 | 2.750E-03 | 1.841E+03 | 1.773E+03 | 3.614E+03 |           |
| 104                                   | 10.4  | 10.3  | 1.293E-03 | 1.110E-03 | 2.403E-03 | 1.699E+03 | 1.459E+03 | 3.158E+03 |           |
| 105                                   | 10.5  | 10.4  | 1.191E-03 | 8.966E-04 | 2.088E-03 | 1.565E+03 | 1.178E+03 | 2.744E+03 |           |
| 106                                   | 10.6  | 10.5  | 1.098E-03 | 6.791E-04 | 1.777E-03 | 1.443E+03 | 8.926E+02 | 2.336E+03 |           |
| 107                                   | 10.7  | 10.6  | 1.012E-03 | 4.679E-04 | 1.480E-03 | 1.330E+03 | 6.150E+02 | 1.945E+03 |           |
| 108                                   | 10.8  | 10.7  | 9.325E-04 | 3.165E-04 | 1.249E-03 | 1.226E+03 | 4.160E+02 | 1.642E+03 |           |
| 109                                   | 10.9  | 10.8  | 8.594E-04 | 1.968E-04 | 1.056E-03 | 1.130E+03 | 2.587E+02 | 1.388E+03 |           |
| 110                                   | 11.0  | 10.9  | 7.913E-04 | 9.826E-05 | 8.896E-04 | 1.040E+03 | 1.291E+02 | 1.169E+03 |           |
| 111                                   | 11.1  | 11.0  | 7.291E-04 | 2.818E-05 | 7.573E-04 | 9.583E+02 | 3.704E+01 | 9.953E+02 |           |

✓ 22-B

WHC-SD-W379-CDR-001 Rev. 0

TABLE 4:  
MCO Neutron Source Spectra  
(Continued)

| Volume (cc) = 1314337 cm <sup>3</sup> |       |       |           |           |           |           |           |           |           |
|---------------------------------------|-------|-------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| GRP HI                                | LOW   | Spon. | Fiss      | Alpha-n   | Total     | Spon.     | Fiss      | Alpha-n   | Total-MCO |
| NO.                                   | MeV   | MeV   | n/sec/cc  | n/sec/cc  | n/sec/cc  | n/sec     | n/sec     | n/sec     | n/sec     |
| -----                                 | ----- | ----- | -----     | -----     | -----     | -----     | -----     | -----     | -----     |
| 112                                   | 11.2  | 11.1  | 6.712E-04 | 1.414E-05 | 6.853E-04 | 8.822E+02 | 1.858E+01 | 9.008E+02 |           |
| 113                                   | 11.3  | 11.2  | 6.184E-04 | 5.846E-06 | 6.242E-04 | 8.128E+02 | 7.684E+00 | 8.205E+02 |           |
| 114                                   | 11.4  | 11.3  | 5.692E-04 | 6.785E-07 | 5.699E-04 | 7.481E+02 | 8.918E-01 | 7.490E+02 |           |
| 115                                   | 11.5  | 11.4  | 5.237E-04 | 2.530E-07 | 5.240E-04 | 6.883E+02 | 3.325E-01 | 6.887E+02 |           |
| 116                                   | 11.6  | 11.5  | 4.827E-04 | 8.433E-08 | 4.828E-04 | 6.344E+02 | 1.108E-01 | 6.345E+02 |           |
| 117                                   | 11.7  | 11.6  | 4.441E-04 | 1.429E-09 | 4.441E-04 | 5.837E+02 | 1.878E-03 | 5.837E+02 |           |
| 118                                   | 11.8  | 11.7  | 4.086E-04 | 0.000E+00 | 4.086E-04 | 5.370E+02 | 0.000E+00 | 5.370E+02 |           |
| 119                                   | 11.9  | 11.8  | 3.761E-04 | 0.000E+00 | 3.761E-04 | 4.943E+02 | 0.000E+00 | 4.943E+02 |           |
| 120                                   | 12.0  | 11.9  | 3.460E-04 | 0.000E+00 | 3.460E-04 | 4.548E+02 | 0.000E+00 | 4.548E+02 |           |
| 121                                   | 12.1  | 12.0  | 3.181E-04 | 0.000E+00 | 3.181E-04 | 4.181E+02 | 0.000E+00 | 4.181E+02 |           |
| 122                                   | 12.2  | 12.1  | 2.932E-04 | 0.000E+00 | 2.932E-04 | 3.854E+02 | 0.000E+00 | 3.854E+02 |           |
| 123                                   | 12.3  | 12.2  | 2.694E-04 | 0.000E+00 | 2.694E-04 | 3.541E+02 | 0.000E+00 | 3.541E+02 |           |
| 124                                   | 12.4  | 12.3  | 2.474E-04 | 0.000E+00 | 2.474E-04 | 3.252E+02 | 0.000E+00 | 3.252E+02 |           |
| 125                                   | 12.5  | 12.4  | 2.280E-04 | 0.000E+00 | 2.280E-04 | 2.997E+02 | 0.000E+00 | 2.997E+02 |           |
| 126                                   | 12.6  | 12.5  | 2.094E-04 | 0.000E+00 | 2.094E-04 | 2.752E+02 | 0.000E+00 | 2.752E+02 |           |
| 127                                   | 12.7  | 12.6  | 1.924E-04 | 0.000E+00 | 1.924E-04 | 2.529E+02 | 0.000E+00 | 2.529E+02 |           |
| 128                                   | 12.8  | 12.7  | 1.773E-04 | 0.000E+00 | 1.773E-04 | 2.330E+02 | 0.000E+00 | 2.330E+02 |           |
| 129                                   | 12.9  | 12.8  | 1.626E-04 | 0.000E+00 | 1.626E-04 | 2.137E+02 | 0.000E+00 | 2.137E+02 |           |
| 130                                   | 13.0  | 12.9  | 1.498E-04 | 0.000E+00 | 1.498E-04 | 1.969E+02 | 0.000E+00 | 1.969E+02 |           |
| 131                                   | 13.1  | 13.0  | 1.372E-04 | 0.000E+00 | 1.372E-04 | 1.803E+02 | 0.000E+00 | 1.803E+02 |           |
| 132                                   | 13.2  | 13.1  | 1.264E-04 | 0.000E+00 | 1.264E-04 | 1.661E+02 | 0.000E+00 | 1.661E+02 |           |
| 133                                   | 13.3  | 13.2  | 1.162E-04 | 0.000E+00 | 1.162E-04 | 1.527E+02 | 0.000E+00 | 1.527E+02 |           |
| 134                                   | 13.4  | 13.3  | 1.066E-04 | 0.000E+00 | 1.066E-04 | 1.401E+02 | 0.000E+00 | 1.401E+02 |           |
| 135                                   | 13.5  | 13.4  | 9.811E-05 | 0.000E+00 | 9.811E-05 | 1.289E+02 | 0.000E+00 | 1.289E+02 |           |
| 136                                   | 13.6  | 13.5  | 8.962E-05 | 0.000E+00 | 8.962E-05 | 1.178E+02 | 0.000E+00 | 1.178E+02 |           |
| 137                                   | 13.7  | 13.6  | 8.308E-05 | 0.000E+00 | 8.308E-05 | 1.092E+02 | 0.000E+00 | 1.092E+02 |           |
| 138                                   | 13.8  | 13.7  | 7.553E-05 | 0.000E+00 | 7.553E-05 | 9.927E+01 | 0.000E+00 | 9.927E+01 |           |
| 139                                   | 13.9  | 13.8  | 6.980E-05 | 0.000E+00 | 6.980E-05 | 9.174E+01 | 0.000E+00 | 9.174E+01 |           |
| 140                                   | 14.0  | 13.9  | 6.402E-05 | 0.000E+00 | 6.402E-05 | 8.414E+01 | 0.000E+00 | 8.414E+01 |           |
| 141                                   | 14.1  | 14.0  | 5.904E-05 | 0.000E+00 | 5.904E-05 | 7.760E+01 | 0.000E+00 | 7.760E+01 |           |
| 142                                   | 14.2  | 14.1  | 5.389E-05 | 0.000E+00 | 5.389E-05 | 7.083E+01 | 0.000E+00 | 7.083E+01 |           |
| 143                                   | 14.3  | 14.2  | 4.957E-05 | 0.000E+00 | 4.957E-05 | 6.515E+01 | 0.000E+00 | 6.515E+01 |           |
| 144                                   | 14.4  | 14.3  | 4.541E-05 | 0.000E+00 | 4.541E-05 | 5.968E+01 | 0.000E+00 | 5.968E+01 |           |
| 145                                   | 14.5  | 14.4  | 4.165E-05 | 0.000E+00 | 4.165E-05 | 5.474E+01 | 0.000E+00 | 5.474E+01 |           |
| 146                                   | 14.6  | 14.5  | 3.846E-05 | 0.000E+00 | 3.846E-05 | 5.055E+01 | 0.000E+00 | 5.055E+01 |           |
| 147                                   | 14.7  | 14.6  | 3.512E-05 | 0.000E+00 | 3.512E-05 | 4.616E+01 | 0.000E+00 | 4.616E+01 |           |
| 148                                   | 14.8  | 14.7  | 3.239E-05 | 0.000E+00 | 3.239E-05 | 4.257E+01 | 0.000E+00 | 4.257E+01 |           |
| 149                                   | 14.9  | 14.8  | 2.935E-05 | 0.000E+00 | 2.935E-05 | 3.858E+01 | 0.000E+00 | 3.858E+01 |           |
| 150                                   | 15.0  | 14.9  | 2.747E-05 | 0.000E+00 | 2.747E-05 | 3.610E+01 | 0.000E+00 | 3.610E+01 |           |
| TOTALS:                               |       |       | 1.795E+01 | 1.078E+00 | 1.903E+01 | 2.359E+07 | 1.417E+06 | 2.501E+07 |           |

✓ 23-B

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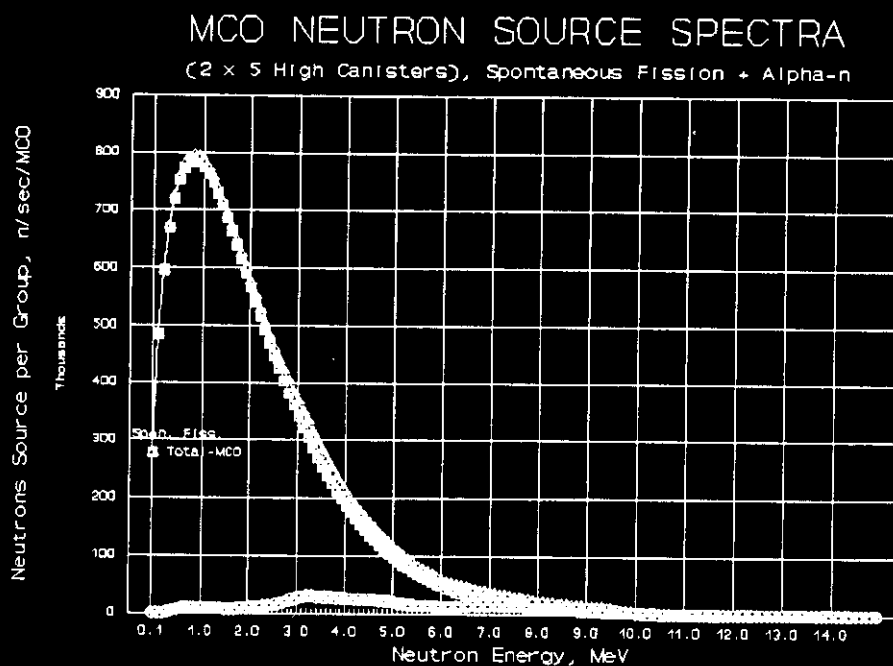


FIGURE 6: MCO NEUTRON SPECTRA

✓ 24-B

### 6.2.1 Scaled Neutron Spectra Plot

If it is assumed that the ORIGEN2.1 code results are more accurate than the SOURCES code, a revised neutron spectrum can be obtained by using the relative neutron spectrum shape from the SOURCES code and scaling it to agree with the total n/sec from the ORIGEN2.1 code. Figure 7 shows the results of the scaling of the neutron spectrum.

## 6.3 Neutron Radiation

The generated neutron fluence rate (flux density) is converted to a dose rate through the use of fluence rate - to - dose rate conversion factors.

### 6.3.1 Neutron Fluence Rate - to - Dose Rate Conversion Factors

The latest version of the *Radiological Control Manual*, DOE N 5480.6, dated April 1994 (Ref. 14), revises the prescription for the neutron quality factor which makes up part of the dose rate conversion factors. Paragraph 128 **Facility Modification and Radiological Design Considerations**, part 1.g, now states that ... *Neutron quality factor of 20 for conditions of unknown spectra (or doubling of the neutron quality factor associated with known neutron energies) should be used for design purposes...* It is assumed that the neutron quality factors to be doubled are those shown in Figure 3, "Quality Factor for Neutrons," *Radiation Protection of Occupational Workers*, DOE Order 5480.11 Change 3, dated 6-17-92 (Ref. 15).

Table 5 shows a summary of various neutron quality factors that have been used in the past, e.g., HWVP used the conversion factors from ICRP-60 (Ref. 16), along with the new "RadCon Manual" (Ref. 14) specified neutron dose rate conversion factors. To be in compliance with the latest version of the "RadCon Manual," those conversion factors given on the right-hand side of Table 4 will be used for the neutron shielding analysis of the CSB/SSF.

### 6.3.2 Neutron Radiation Results

Based on the above discussion of subsections 6.1 and 6.2, it was decided to use the conservative SOURCES code neutron source since this total n/sec source was larger than the ORIGEN2 generated total neutron source. Applying the neutron source as defined in Table 4 to the MCNP-4A input specification results in an MCO contact neutron radiation level of about 86.6 mrem/h. This value is compared to the MCNP-4A gamma radiation level of 497.5 R/h (497,500 mrem/h), or a neutron contribution to the radiation dose rate of 0.017 percent. Although this neutron radiation is a small percentage of the gamma radiation, specific neutron shielding needs

✓ 25-B

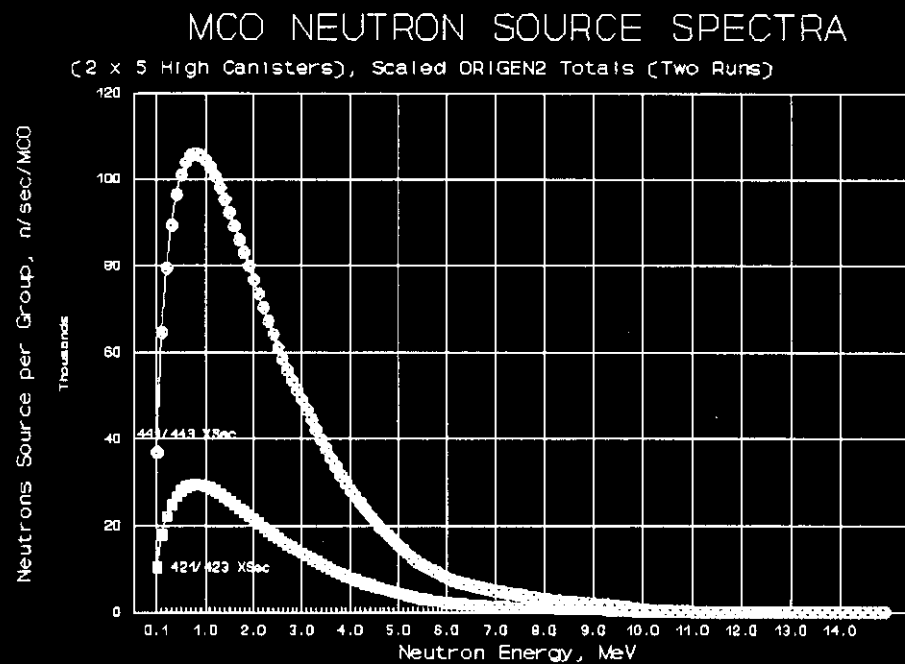


FIGURE 7: ORIGEN2 SCALED TOTALS FOR NEUTRON SPECTRA COMPARISON

✓ 26-B

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TABLE 5:  
SUMMARY OF NEUTRON FLUENCE RATE  
(n/cm<sup>2</sup>-sec) - TO - DOSE RATE (mrem/h)  
CONVERSION FACTORS

| Neutron<br>Energy<br>MeV | Per DOE ORDER 5480.11<br>(Ref. 15) |                      |                        | Per ICRP-60 (Ref. 16)<br>(Used on HWVP) |                        |       | Per RadCon Manual<br>April 1994 (Ref. 14) |                        |       | Per RadCon Manual<br>April 1994 (Ref. 14) |                        |       |
|--------------------------|------------------------------------|----------------------|------------------------|-----------------------------------------|------------------------|-------|-------------------------------------------|------------------------|-------|-------------------------------------------|------------------------|-------|
|                          | Qual                               | n/(cm <sup>2</sup> ) | mrem/h                 | Qual                                    | mrem/h                 | Ratio | Qual                                      | mrem/h                 | Ratio | Qual                                      | mrem/h                 | Ratio |
|                          | Fact                               |                      | Per                    | Fact                                    | Per                    | Q1/Q2 | Fact                                      | Per                    | Q2/Q3 | Fact                                      | Per                    | Q3/Q4 |
|                          | Q1                                 |                      | n/(cm <sup>2</sup> -s) | Q2                                      | n/(cm <sup>2</sup> -s) |       | Q3                                        | n/(cm <sup>2</sup> -s) |       | Q4                                        | n/(cm <sup>2</sup> -s) |       |
|                          | Note 1                             |                      |                        | Note 2                                  |                        |       | Note 3                                    |                        |       |                                           |                        |       |
| 2.50E-08                 | 2                                  | 680                  | 3.68E-03               | 5                                       | 9.19E-03               | 2.50  | 4                                         | 7.36E-03               | 1.25  | 20                                        | 3.68E-02               | 0.20  |
| 1.00E-07                 | 2                                  | 680                  | 3.68E-03               | 5                                       | 9.19E-03               | 2.50  | 4                                         | 7.36E-03               | 1.25  | 20                                        | 3.68E-02               | 0.20  |
| 1.00E-06                 | 2                                  | 560                  | 4.46E-03               | 5                                       | 1.12E-02               | 2.50  | 4                                         | 8.92E-03               | 1.25  | 20                                        | 4.46E-02               | 0.20  |
| 1.00E-05                 | 2                                  | 560                  | 4.46E-03               | 5                                       | 1.12E-02               | 2.50  | 4                                         | 8.92E-03               | 1.25  | 20                                        | 4.46E-02               | 0.20  |
| 1.00E-04                 | 2                                  | 580                  | 4.31E-03               | 5                                       | 1.08E-02               | 2.50  | 4                                         | 8.62E-03               | 1.25  | 20                                        | 4.31E-02               | 0.20  |
| 1.00E-03                 | 2                                  | 680                  | 3.68E-03               | 5                                       | 9.19E-03               | 2.50  | 4                                         | 7.36E-03               | 1.25  | 20                                        | 3.68E-02               | 0.20  |
| 1.00E-02                 | 2.5                                | 700                  | 3.57E-03               | 10                                      | 1.43E-02               | 4.00  | 5                                         | 7.14E-03               | 2.00  | 20                                        | 2.86E-02               | 0.25  |
| 1.00E-01                 | 7.5                                | 115                  | 2.17E-02               | 10                                      | 2.90E-02               | 1.33  | 15                                        | 4.34E-02               | 0.67  | 20                                        | 5.79E-02               | 0.75  |
| 5.00E-01                 | 11                                 | 27                   | 9.26E-02               | 20                                      | 1.68E-01               | 1.82  | 22                                        | 1.85E-01               | 0.91  | 20                                        | 1.68E-01               | 1.10  |
| 1.00E+00                 | 11                                 | 19                   | 1.32E-01               | 20                                      | 2.39E-01               | 1.82  | 22                                        | 2.64E-01               | 0.91  | 20                                        | 2.40E-01               | 1.10  |
| 2.50E+00                 | 9                                  | 20                   | 1.25E-01               | 10                                      | 1.39E-01               | 1.11  | 18                                        | 2.50E-01               | 0.56  | 20                                        | 2.78E-01               | 0.90  |
| 5.00E+00                 | 8                                  | 16                   | 1.56E-01               | 10                                      | 1.95E-01               | 1.25  | 16                                        | 3.12E-01               | 0.63  | 20                                        | 3.90E-01               | 0.80  |
| 7.00E+00                 | 7                                  | 17                   | 1.47E-01               | 10                                      | 2.10E-01               | 1.43  | 14                                        | 2.94E-01               | 0.71  | 20                                        | 4.20E-01               | 0.70  |
| 1.00E+01                 | 6.5                                | 17                   | 1.47E-01               | 10                                      | 2.26E-01               | 1.54  | 13                                        | 2.94E-01               | 0.77  | 20                                        | 4.52E-01               | 0.65  |
| 1.40E+01                 | 7.5                                | 12                   | 2.08E-01               | 10                                      | 2.78E-01               | 1.33  | 15                                        | 4.16E-01               | 0.67  | 20                                        | 5.55E-01               | 0.75  |
| 2.00E+01                 | 8                                  | 11                   | 2.27E-01               | 10                                      | 2.84E-01               | 1.25  | 16                                        | 4.54E-01               | 0.63  | 20                                        | 5.68E-01               | 0.80  |
| 4.00E+01                 | 7                                  | 10                   | 2.50E-01               | 5                                       | 1.79E-01               | 0.71  | 14                                        | 5.00E-01               | 0.36  | 20                                        | 7.14E-01               | 0.70  |
| 6.00E+01                 | 5.5                                | 11                   | 2.27E-01               | 5                                       | 2.07E-01               | 0.91  | 11                                        | 4.54E-01               | 0.45  | 20                                        | 8.25E-01               | 0.55  |
| 1.00E+02                 | 4                                  | 14                   | 1.79E-01               | 5                                       | 2.23E-01               | 1.25  | 8                                         | 3.58E-01               | 0.63  | 20                                        | 8.95E-01               | 0.40  |
| 2.00E+02                 | 3.5                                | 13                   | 1.92E-01               | 5                                       | 2.75E-01               | 1.43  | 7                                         | 3.84E-01               | 0.71  | 20                                        | 1.10E+00               | 0.35  |
| 3.00E+02                 | 3.5                                | 11                   | 2.27E-01               | 5                                       | 3.25E-01               | 1.43  | 7                                         | 4.54E-01               | 0.71  | 20                                        | 1.30E+00               | 0.35  |
| 4.00E+02                 | 3.5                                | 10                   | 2.50E-01               | 5                                       | 3.57E-01               | 1.43  | 7                                         | 5.00E-01               | 0.71  | 20                                        | 1.43E+00               | 0.35  |

Note 1: Neutron flux density (fluence rate) which results in 100 mrem in 40 hours (basis for conversion factors)

Note 2: Use for Known Neutron Energy Spectrum (Q3 = 2 x Q1)

Note 3: Use for Unknown Neutron Energy Spectrum and per Old RadCon Manual, June '92 (Use Estimated "Average" Energy)

to be sized for the shielded cask to reduce the contact dose rate to less than 20 mrem/h.

Given the activation potential of the neutrons for nearby personnel and the re-usable shielded cask and associated equipment materials, it is recommended that the neutron radiation on contact at the shield cask surface be less than 0.2 mrem/h (1/100 times the allowable gamma radiation level of 20 mrem/h on contact). Neutron shielding analysis needs to be performed to size the thickness of low-Z neutron shield (e.g., borated polyethylene).

## 7. Shielding Criteria

### 7.1 Radiation Dose Limit Considerations

It is well recognized that DOE 5480.11, *Radiation Protection For Occupational Workers* (Ref. 15), specifies a maximum yearly effective dose equivalent (EDE) of 5 Rem. However, 5480.11 does not mention a quarterly dose. In addition, 10CFR20 (Ref. 17) stipulates a maximum yearly dose of 5 Rem and it is also silent on the question of a quarterly dose. It should be noted that these limits are not considered to be ALARA. However, in the past, the NRC did specify a quarterly dose of 3 Rem so long as the yearly dose did not exceed 5 Rem. This quarterly dose was specified in earlier versions of 10CFR20 and it was applied to reactor operations. Reactor operators generally applied this quarterly dose to contract labor and not to permanent employees. One could speculate that the DOE never used the quarterly dose system because, the DOE and its prime contractors rarely use contract labor. However, the use of contract workers could dramatically increase in the future if the DOE changes its mode of operations and actuates new schemes such as "privatization". Suffice it to say, that the CSB/SSF Conceptual Design must be tied to the current DOE annual dose limits. The methodology, shown below, for facility design and contact maintenance is applicable regardless of the annual or quarterly dose limits.

In 1989 the DOE 6430.1A, *General Design Criteria* (Ref. 18), stated "personnel exposure shall be maintained ALARA. The projected dose rates based on occupancy, time, and frequency of exposure shall not exceed 1 Rem/yr." In 1992, the DOE/EH-0256T, *Radiological Control Manual* (Ref. 19), stated "Individual worker dose should be ALARA and less than 500 mrem/yr." Consequently, the Westinghouse Hanford Company (WHC) issued HSRCM-1, *Hanford Site Radiological Manual* (Ref. 20), and WHC-CM-1-6, *Radiological Control Manual* (Ref. 21). The WHC *Radiological Control Manual* (Ref. 14) adopted an initial goal of 500 mrem/yr for employees. Finally, in April of 1994, revision 1 of DOE/EH-0256T, *Radiological Control Manual*, stated "Individual worker dose shall be ALARA and should be less than 500 mrem/yr." It is apparent in this revision that ALARA goes from a

suggestion to a directive. Thus, specifying the change from "should" to "shall".

It is obvious from the data shown above, that the DOE trend in annual dose limits for radiation workers has continuously declined. Thus, it is unlikely that any new contract schemes will alter the current trend in declining annual dose limits will so long as the DOE has jurisdiction over the contracts.

These new annual limits, however, which are ten times lower than they have been in the recent past, place an enormous burden on the facility designers as well as the operations and maintenance (O&M) contractors to comply with them. Thus, designers of new facilities and major alterations to existing facilities must find new ways to meet these new dose limits. The only tools available to designers are "source", "shielding", "time", "distance" and whether the operation is contact or remote. These new limits have also caused the O&M contractors to redefine the radiation dose rate limits in areas that radiation workers may enter. These problems are further exacerbated by the fact that existing DOE and local regulations have not been altered since the new annual dose limits have been specified, and they consistently conflict.

In order to meet the criteria shown above, WHC has been required to redesignate Radiation Access Zones (RAZs) as follows:

| RADIATION ACCESS ZONE | OCCUPANCY GUIDELINES       | RADIATION LEVEL                  |
|-----------------------|----------------------------|----------------------------------|
| Uncontrolled          | Full Time                  | 0.5 $\mu$ Sv/h<br>(0.05 mrem/h)  |
| 1                     | 40 hours per week          | 2.5 $\mu$ Sv/h<br>(0.25 mrem/hr) |
| 2                     | 1 hour per day<br>maximum  | 0.02 mSv/h<br>(2.0 mrem/hr)      |
| 3                     | 1 hour per week<br>maximum | 0.1 mSv/h<br>(10 mrem/hr)        |
| 4                     | 10 hours per year          | 0.5 mSv/h<br>(50 mrem/hr)        |
| 5                     | No normal access           | > 0.5 mSv/h<br>(>50 mrem/hr)     |

It can be seen that while these zone designations are sufficient to meet the criteria shown above, for annual dose limits, these RAZs practically eliminate maintenance activities in anything except in RAZ 1 and uncontrolled areas. Thus, they would practically eliminate a contact maintained facility. In addition, there is the

question of conflicting regulations. For example, WHC-EP-0063-3, the *Hanford Solid Waste Acceptance Criteria* (Ref. 22a), permits contact maintenance of solid waste drums with surface dose rates up to 200 mrem/h. However, this drum would create a RAZ 5, which does not permit entrance into an area with a dose rate above 50 mrem/h. Thus, this contact maintainable drum could never have anyone in the same room with it. There are many other conflicts that have been created because new regulations seem to be generated without regard to existing criteria and there doesn't seem to be any regulatory body that brings existing criteria into compliance with existing regulations

The situation described above calls for a new look at an old solution. Fluor Daniel, Inc., (FDI) Health Physics (HP) suggests that one possible and defensible solution to contact maintenance is to return to the concept of a quarterly dose. However, since the new yearly dose is 500 mrem, then the quarterly dose should be 300 mrem. Please note that a maintenance worker who receives 300 mrem in one quarter cannot receive more than 200 mrem in the next three quarters. This will mean additional workers on a project but that seems to be the cost of these lower dose rate criteria at least as far as contact maintenance is concerned.

Thus, the FDI Shielding and HP groups will evaluate contact maintenance operations as follows:

- 1) In order to perform an initial analysis in a radioactive waste treatment facility, it will be assumed that all maintenance in RAZ 2 and above will be performed in a full face respirator with HEPA filters so that the internal dose is limited to radioactive gases such as radon, thoron ( $^{232}\text{Th}$ ) or iodine. It is further assumed that the internal dose will not exceed more than ten percent of the external, whole body dose.
- 2) If the sum of the direct and indirect radiation fields exceeds a whole body dose rate of 50 mrem/h, then the operation must be remote.
- 3) If the sum of the direct and indirect dose rates multiplied by the number of hours of the maximum exposed individual worker exceeds 300 mrem, then the operation must be remote.
- 4) If the whole body dose rate from all possible sources does not exceed 50 mrem/h and if the sum of the direct and indirect dose rates multiplied by the number of hours of the maximum exposed individual worker is less than or equal to 300 mrem, then the operation can be contact maintained.

The four steps shown above will be used as the determining factor as to whether an operation is contact maintained or remote.

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## 7.2 RADIATION ACCESS ZONE DESIGNATIONS

There is an apparent conflict between the internal and external dose limits. Based on the need to include internal dose contribution (primarily inhalation), the RAZ designation dose rate limits were interpreted to be total Committed Effective Dose Equivalents (CEDE) values. The following table is offered as a possible RAZ summary table which addresses both the internal and external dose limit considerations:

| RAZ DESIGNATION | TOTAL CEDE DOSE RATE | OCCUPANCY GUIDELINES         | DESCRIPTION                                          | NOTES                               |
|-----------------|----------------------|------------------------------|------------------------------------------------------|-------------------------------------|
| Uncontrolled    | 0.05 mrem/h          | Full Time                    | No Posting                                           | 0.0 DAC                             |
| RAZ 1           | 0.25 mrem/h          | 40 hours per week            | No Posting<br>40 %<br>External*<br>60 %<br>Internal* | < 0.1 DAC                           |
| RAZ 2           | 2.0 mrem/h           | 1 hour per day<br>maximum    | Case-By-Case**                                       | Respirator<br>for $\geq 1$ DAC      |
| RAZ 3           | 10.0 mrem/h          | 10 hours per week<br>maximum | Case-By-Case**                                       | Respirator<br>for $\geq 1$ DAC      |
| RAZ 4           | 50.0 mrem/h          | 10 hours per year<br>maximum | Case-By-Case**                                       | Respirator<br>for $\geq 1$ DAC      |
| RAZ 5           | >50.0<br>mrem/h      | No normal access             | No Access                                            | Respirator<br>for Emergency<br>Only |

\* Note: 40% external implies 0.1 mrem/h and 60% internal implies 0.15 mrem/h.

\*\* Note: Total dose (external + internal) for one year shall not exceed 500 mrem

## 8. RADIATION AND SHIELDING ANALYSIS METHODS

The Fluor Daniel design team has available a large selection of radiation and shielding analysis computer programs representing a wide range of capability to best suit the specific analysis requirements. Table 6 provides a listing of these available codes along with their potential use on the CSB/SSF Conceptual Design.

### 8.1 Choice of Computer Models

The principal tool selected for shielding and criticality calculations is the PC version of MCNP, Version 4A, developed and supported by the Los Alamos National Laboratory (LANL), Reference 2. This code was selected because of its great flexibility, high

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2. This code was selected because of its great flexibility, high

TABLE 6

RADIATION SHIELDING CODES USED BY FDI FOR VARIOUS APPLICATIONS

A Full Range of Radiation Shielding Capability is Available to Support All Phases of Design in a Cost Effective Approach:

| PURPOSE/<br>FUNCTION                                          | CODE NAME                         | V & V    | CSB/SSF CONCEPTUAL DESIGN USE      |
|---------------------------------------------------------------|-----------------------------------|----------|------------------------------------|
| Gamma-Ray<br>Source<br>Group/Spectra<br>From<br>Radionuclides | SOURCES                           | By WHC   | N-Fuel Neutron Source<br>Spectrum  |
|                                                               | ORIGEN-2.1                        | By FDI   | Total Neutron Source (Check)       |
|                                                               | RADDECAY-4                        | For HWVP | Radioisotope Decay Chains          |
|                                                               | LOTUS-123                         | For HWVP | Beta Spectra for<br>Bremsstrahlung |
| Simple<br>Geometry<br>Gamma-Ray<br>Shielding                  | ISO-PC,<br>Version 1.98           | By FDI   | Bremsstrahlung Analysis            |
|                                                               | MicroShield-4.10                  | For HWVP | Gamma Shielding                    |
| Complex/<br>General<br>Geometry<br>Gamma-Ray<br>Shielding     | QAD-CGGP<br>(Single Source)       | By FDI   | Not Used                           |
|                                                               | QAD-CG5<br>(Multi-Source)         | For HWVP | Not Used                           |
|                                                               | MCNP-4A                           | For HWVP | Gamma Radiation/Shielding          |
| Gamma-Ray<br>Scattering<br>Analysis                           | MicroSkyshine                     | For HWVP | Not Used (Single Air Scatter)      |
|                                                               | MCNP-4A                           | For HWVP | Gamma Scattering/Streaming         |
| Neutron/<br>2'dary Gamma<br>Shielding                         | ANISN-W                           | By FDI   | Not Used (1-D, Multi-Group)        |
|                                                               | MCNP-4A                           | For HWVP | Cask Neutron Shielding             |
| Criticality<br>Analysis                                       | KENO-5 (Part Of<br>SCALE Package) | By FDI   | Criticality Verification           |
|                                                               | MCNP-4A                           | For HWVP | Criticality Surveys                |
| Release<br>Dose<br>Exposure                                   | GENII-S                           | TBD      | Not Used                           |
|                                                               | AIRDOS-PC                         | TBD      | Not Used                           |

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fidelity modeling, and the ability to perform both shielding and criticality calculations.

The version of MCNP used at FDI was obtained from RSIC. The only modifications performed on this code was to adjust the size of the array MDAS, as recommended by the code developer, to allow the code to run on PCs with various RAM sizes. The code was compiled with the Lahey Fortran 77 compiler, F77L-EM/32, Version 5.01, Reference 23.

Neutron cross-sections used in the criticality calculations were selected from the ENDEF/B-V continuous energy cross-section library distributed with MCNP (Reference 2). This library provides reaction cross-section data tabulated at a sufficiently large number of energy points to allow linear-linear interpolation between data points well within the uncertainties of the data.

MicroShield Version 4.10 (Ref. 9), another radiation shielding code, was used to generate bulk shielding requirements for gamma radiation; its applicability is limited to simple source distributions and shield geometries.

ISO-PC, Version 1.98 (Ref. 10) is a new version of the original point-kernel radiation shielding code ISOSHL D II. The ISO-PC code has updated many of the features of ISOSHL D II, added more materials and corrected some errors in the ISOSHL D II code. ISO-PC calculates bremsstrahlung radiation from beta sources and runs extremely fast due to the FORTRAN-77 compilation execution files. This code is an excellent radiation shielding program for conceptual design radiation analysis.

## 8.2 CODE VERIFICATION AND VALIDATION

All shielding and criticality codes used for this study have been verified by running the test problems supplied with the code packages. The test problem results are shown to be in agreement either with the published documentation supplied as part of the code package, or with the sample problem output, if provided. This information is documented, dated, and retained on file. Any changes, such as upgrades, corrections, modifications, etc., are incorporated into the documentation following rerunning of the verification problems.

The MicroShield code is a commercially available code which is supplied with a verification and validation package. This package includes a test problem set which compared the results of these programs to those from other industry standard, noncommercial programs for both mainframe and personal computers. The test cases used were the ANSI/ANS-6.6.1 (Ref. 24) and the ESIS Reference Cases (Ref. 25). These test cases were run using the MicroShield codes obtaining agreement with the published results. The results were

dated, documented, and retained in the various program documentation files.

MCNP Version 4A (Ref. 2) is the latest version of a widely used and well accepted radiation transport code employed for a wide variety of radiation analyses including neutron, photon and electron transport, and criticality. LANL has performed extensive calculations with MCNP, duplicating a wide range of experimental results, to validate the models contained in this code. The results of these benchmark cases are documented in References 26 and 27. The version of MCNP4A used at Fluor Daniel was tested by exercising the twenty-five sample problems supplied by LANL, and the results were found to be in agreement within reasonable statistical limits. These sample problems are designed to exercise a broad range of the code's computational capabilities, including criticality calculations, which is addressed by five of the twenty-five sample problems.

### 8.3 FLUENCE RATE TO DOSE RATE CONVERSION

Once a gamma or neutron fluence rate (particle/cm<sup>2</sup>-sec) has been calculated by the appropriate computer code, the code must convert this fluence rate to an absorbed dose rate in humans in units of rem/h or mrem/h (rem = Roentgen Equivalent Man). The conversion is dependent both on the type of particle ( $\gamma$  or n) and the energy of the particle. The conversion factors for gamma exposure (built into MicroShield) are based on ICRP-51 (Ref. 28) and ANSI/ANS-6.1.1-1991 (Ref. 29) and are given in Table 7. Dose rate conversion factors for neutrons are discussed in Section 6.3 and are given in Table 5.

| Table 7                                                              |                                                                |                        |                                                                |
|----------------------------------------------------------------------|----------------------------------------------------------------|------------------------|----------------------------------------------------------------|
| Fluence Rate to Dose Rate Conversion Factors for Gammas<br>(Ref. 28) |                                                                |                        |                                                                |
| PHOTON ENERGY<br>(MeV)                                               | CONVERSION FACTOR<br>(mrem/hr) / (Ph/cm <sup>2</sup> -<br>sec) | PHOTON ENERGY<br>(MeV) | CONVERSION FACTOR<br>(mrem/hr) / (Ph/cm <sup>2</sup> -<br>sec) |
| 1.00E-02                                                             | 0.00002232                                                     | 5.00E-01               | 0.0009144                                                      |
| 1.50E-02                                                             | 0.00005652                                                     | 6.00E-01               | 0.0010764                                                      |
| 2.00E-02                                                             | 0.00008568                                                     | 8.00E-01               | 0.001379                                                       |
| 3.00E-02                                                             | 0.0001184                                                      | 1.00E+00               | 0.001656                                                       |
| 4.00E-02                                                             | 0.0001314                                                      | 1.50E+00               | 0.002246                                                       |
| 5.00E-02                                                             | 0.0001382                                                      | 2.00E+00               | 0.002758                                                       |
| 6.00E-02                                                             | 0.0001440                                                      | 3.00E+00               | 0.003672                                                       |
| 8.00E-02                                                             | 0.0001624                                                      | 4.00E+00               | 0.004500                                                       |
| 1.00E-01                                                             | 0.0001919                                                      | 5.00E+00               | 0.005292                                                       |
| 1.50E-01                                                             | 0.0002797                                                      | 6.00E+00               | 0.006012                                                       |
| 2.00E-01                                                             | 0.0003708                                                      | 8.00E+00               | 0.007488                                                       |
| 3.00E-01                                                             | 0.0005616                                                      | 1.00E+01               | 0.008892                                                       |
| 4.00E-01                                                             | 0.0007416                                                      | 1.20E+01               | 0.010404                                                       |

#### 8.4 GUIDELINES FOR STATISTICALLY ADEQUATE RESULTS

Monte Carlo shielding analyses codes (e.g., MCNP4A) rely on sampling a large number of particles and tracing them throughout the modeled geometry. Since the results are a function of the number of initial source particles sampled and the number of particles reaching the specified dose points, the resulting mean "detected" dose rates have an implied statistical uncertainty (relative error) associated with them. Depending on the degree of attenuation and the complexity of the sample space, achieving unrealistically low relative errors can be extremely time-consuming (e.g., days of PC computing time) and expensive (additional labor time and potential schedule impacts). In order to place some practical limits on relative errors, the following guidelines on acceptable uncertainty ranges are established. Table 8, based on a similar table in Reference 2, presents interpretations of the relative errors with regard to the quality of the results:

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| TABLE 8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                  |                                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|------------------------------------------|
| Guidelines for Interpreting MCNP 4A Relative Error                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                  |                                          |
| Upper Limit Relative to the Calculated Mean                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                  |                                          |
| Range of Relative Error<br>(Note 1)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Surface/Volume Tally<br>(Note 2) | Point Detector<br>(Note 3)               |
| 0.35 to 1.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Unacceptable                     | Unacceptable                             |
| 0.2 to 0.35                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Within Factor of 5               | Unacceptable                             |
| 0.1 to 0.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Within Factor of 2               | Within Factor of 5                       |
| 0.05 to 0.1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Within $3\sigma$ Uncertainty     | Within Factor of 2                       |
| <0.05                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Within $3\sigma$ Uncertainty     | Within $6\sigma$ Uncertainty<br>(Note 4) |
| <p>(1) The relative error represents the standard deviation, <math>1\sigma</math>, in the estimated quantity. These interpretations of relative error assume that all relevant portions of the problem geometry are well sampled by the Monte Carlo process. Print Table 126 of the MCNP output should be reviewed to assure sampling adequacy.</p> <p>(2) Care should be exercised in selecting tally surface areas and cell volumes so as not to "wash out" hot spots in the geometry by averaging the resulting dose rate over an excessively large area/volume.</p> <p>(3) It is very important that Table 126 be examined to assure that a substantial number of events is occurring in all significant propagation paths between the source and the point detector. If the detectors are embedded in a medium (rather than a void), the radius of the sphere about the detector on the f5 card should be somewhere between 0.2 and 1.0 mean free path. It is good practice to use surface/volume tallies in conjunction with the point detector to further verify its reliability. The point detector diagnostics printout (invoked by the DD card) should also be reviewed to assure adequate relevant-region sampling.</p> <p>(4) <math>6\sigma</math> at 5% relative error translates to about <math>\pm 30\%</math>. Caution should always be used in interpreting results from point detector tallies. Uncertainty estimates of point detector tallies can quickly converge to a low value before all important variations of the problem are properly sampled; variance reduction techniques, available with point detectors, can distort (i.e., bias) results unless associated probability distributions are fully sampled.</p> |                                  |                                          |

The upper limits identified in Table 8 will represent the worst-case level as estimated by the calculations. Thus, if the mean +  $3\sigma$  or mean times the factor are within criteria level, the calculation will be assumed complete and the shielding or other protective measures satisfactory. For fast running calculations, small relative errors can and will be achieved. At issue are those calculations which, for one reason or another, require very long run times to achieve any kind of acceptable relative errors.

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(Lower levels, i.e., the mean minus the  $3\sigma$  or the mean divided by the factor, will only be considered if they represent the conservative levels; this would be the case if the highest achieved levels are the objective.)

Table 126 of the MCNP output indicates how well the geometry is sampled. This table should be consulted to assure oneself that the statistics (i.e., the mean and relative error) are representative of the problem as a whole.

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15. DOE Order 5480.11, "Radiation Protection for Occupational Worker," Change 3, dated June 17, 1992.
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19. DOE-EH-0256T, "Radiological Control Manual," dated June, 1992.
20. HSRCM-1, "Hanford Site Radiological Control Manual," Revision 2, dated December 9, 1994.
21. WHC-CM-1-6, "WHC Radiological Control Manual," Rev 1, dated October 15, 1995
22. WHC-EP-0063, "Hanford Radioactive Solid Waste Packaging, Storage, and Disposal Requirements," dated September, 1988.
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**B. APPLICABLE CODES AND STANDARDS**

The following radiation safety related codes and standards shall be applied to the design of the Staging and Storage Facility:

1. DOE Order 6430.1A, "General Design Criteria," 1989.
2. DOE Order 5480.1B, "Environmental, Safety, and Health Protection for Department of Energy Operations."
- 3a. WHC-EP-0063, "Hanford Radioactive Solid Waste Packaging, Storage, and Disposal Requirements," dated September, 1988.
3. WHC-EP-0063-3, "Hanford Waste Acceptance Criteria," dated September 1991
4. DOE Order 5480.11, "Radiation Protection for Occupational Worker," Change 3, dated June 17, 1992.
5. DOE Order 5820.2A, "Radioactive Waste Management," 1988.
6. DOE Order 55632 Series, "Physical Protection of Special Nuclear Material."
7. DOE Order 5480.22, "Technical Safety Requirements."
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9. DOE N5480.6, DOE-EH-0256T, "Radiological Control Manual," dated June, 1992.
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C. NATIONAL CODES AND STANDARDS

1. ASME NQA-1, "Quality Assurance Requirements for Nuclear Facility Applications."
2. ANSI/ANS 8.1, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside the Reactor."
3. ANSI/ANS 8.12, "Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside the Reactor."
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D. WESTINGHOUSE HANFORD COMPANY (WHC) DOCUMENTS

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"MCNP: Neutron Benchmark Problems," Los Alamos National  
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## APPENDIX VI

### Process Engineering Data

- A. Heat Release - Storage Area
- B. Utility Summaries

## APPENDIX VI. A

### CONCEPT "2D" HEAT RELEASE - STORAGE AREA

#### OBJECTIVE

Changes have occurred in the number of MCOs and in the heat release rates. Hence, the total heat release must be recalculated.

#### BASIS FOR CALCULATION

1. Staging and Storage Facility - Feasibility Study - Final Report
2. Statement of Work - Conceptual Design of the HWVP Canister Storage Building of a Staging and Storage Facility for Spent Nuclear Fuels
3. Louis H. Goldman (WHC) to Craig E. Swenson (WHC) - "MCO information per your request" - 05/06/95

#### LIST OF ASSUMPTIONS

- |                                      |   |           |                                           |
|--------------------------------------|---|-----------|-------------------------------------------|
| 1. Tubes per Vault                   | = | 220       | Canister<br>Storage<br>Building<br>Design |
| 2. MCO's per Tube                    | = | 2         | Basis 1                                   |
| 3. Vaults used for Staging           | = | 2         | Basis 1                                   |
| 4. Total MCOs (Design Basis)         | = | 750       | Basis 2                                   |
| 5. "Normal" MCOs (for Heat Release)  | = | 80 %      | Reference 1                               |
| 6. "Maximum" MCOs (for Heat Release) | = | 20 %      | Reference 1                               |
| 7. Heat Release per MCO (Normal)     | = | 221 watts | Basis 3                                   |
| 8. Heat Release per MCO (Maximum)    | = | 426 watts | Basis 3                                   |

#### LIST OF REFERENCES

1. Fluor Daniel InterOffice Correspondence - Phil Bedell - "MCO Characteristics" - 05/10/95

## CALCULATION

Total MCOs which could be stored = 220 tubes/vault x 2 vaults x 2  
MCOs/tube = 880

Heat release (Total MCOs) =  $(0.8 \times 221) + (0.2 \times 426)$  watts/MCO x  
880 MCOs = 231,000 watts or 0.79 MMBtu/hr

Heat release (Design Basis) =  $(0.8 \times 221) + (0.2 \times 426)$  watts/MCO  
x 750 MCOs = 197,000 watts or 0.67 MMBtu/hr

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## APPENDIX VI. B

### CONCEPT "2D" UTILITY SUMMARIES

#### SANITARY WATER

|                                        |                |          |
|----------------------------------------|----------------|----------|
| Wash Area (See Calculations Below)     | 3,000 GPD      | 2.08 gpm |
| Process Water (See Calculations Below) | <u>4,800</u> " | 3.36 "   |
| Totals                                 | 7,800 "        | 5.44 "   |

#### Wash Area Requirements

|                          |     |         |
|--------------------------|-----|---------|
| Flush Rate (Assumed)     | 100 | gpm     |
| Flush Duration (Assumed) | 15  | minutes |
| Operations/Day (Basis)   |     | 2       |

Gallons per Operation = 100 gpm x 15 minutes = 1,500

Daily Requirement = 1,500 gallons/  
operation x 2 Operations/Day 3,000 GPD

#### Process (Compressor) Water Requirements

|               |             |
|---------------|-------------|
| Air Flow      | 448 #/hr    |
| Specific Heat | 0.237 Btu/# |

|                          |       |
|--------------------------|-------|
| Water Inlet Temperature  | 70 °F |
| Water Outlet Temperature | 80 °F |

|                                       |        |
|---------------------------------------|--------|
| First Stage Outlet Temperature        | 314 °F |
| First Stage Cooler Outlet Temperature | 90 °F  |

First Stage Heat Release = 448 Btu/#  
/ 0.237 Btu/#-°F x (314 - 90) °F = 0.42 MMBtu/hr

First Stage Water Required = x gpm/500 #/hr = 840 #/hr  
1,000,000 x 0.42 MMBtu/hr x #-°F/Btu or  
1.68 gpm

|                                        |        |
|----------------------------------------|--------|
| Second Stage Outlet Temperature        | 311 °F |
| Second Stage Cooler Outlet Temperature | 90 °F  |

Second Stage Heat Release = 448 Btu/# / 0.237  
Btu/#-°F x (311 - 90) °F = 0.42 MMBtu/hr

Second Stage Water Required = 1,000,000  
x 0.42 MMBtu/hr x #-°F/Btu x gpm/500 #/hr = 840 #/hr  
or  
1.68 gpm

Total Process (Compressor) Water Required = 3.36 "

## APPENDIX VII

### SYSTEMS ENGINEERING DATA

(Extracts from CORE "System Description Document")

1. Requirements Traceability Matrix
- ...
7. Functional Behavior Model Examples



# 1 Requirements Traceability Matrix

| Allocated Capabilities/Requirements                                          | Traced From Higher-Level Elements                                                                                                                                                                                                                                                                                                                                                                                   |
|------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5 - No Toxic Chemicals (of significant amts) Used in CSB Design (Constraint) |                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 17 - Maximum Wind Velocity (Constraint)                                      |                                                                                                                                                                                                                                                                                                                                                                                                                     |
| F.1 - Protect Health & Safety (Function)                                     | 3.0 - Technical Requirements (OriginatingRequirement)<br>3.2 - Safety Design Criteria (OriginatingRequirement)<br>3.2.2 - ALARA Design Goal (OriginatingRequirement)<br>3.3.1 - Occupational Health & Safety (OriginatingRequirement)<br>3.3.1.1 - Shielding Criteria (OriginatingRequirement)<br>3.3 - Regulatory Compliance (OriginatingRequirement)<br>3.3.1.2 - Shielding Source Terms (OriginatingRequirement) |
| F.1.3.6 - Withstand a Design Basis Volcano Eruption (Function)               | 3.2.3.6 - Design Basis Ashfall (OriginatingRequirement)<br>3.2.3 - Design Basis Accidents (OriginatingRequirement)<br>3.2 - Safety Design Criteria (OriginatingRequirement)                                                                                                                                                                                                                                         |
| F.2 - Staging Function (Function)                                            | 3.1 - Functional Requirements (OriginatingRequirement)<br>3.0 - Technical Requirements (OriginatingRequirement)                                                                                                                                                                                                                                                                                                     |
| F.2.1.3 - Receive empty MCOs (Function)                                      | 3.1.1 - Empty - MCO(0) - Receipt & Handling (OriginatingRequirement)<br>3.1 - Functional Requirements (OriginatingRequirement)<br>3.0 - Technical Requirements (OriginatingRequirement)                                                                                                                                                                                                                             |
| F.3.1 - Stage MCO(K)s (Function)                                             | 3.1.3 - Process MCO(K) to MCO(S) (OriginatingRequirement)<br>3.1 - Functional Requirements (OriginatingRequirement)<br>3.0 - Technical Requirements (OriginatingRequirement)                                                                                                                                                                                                                                        |

# 1 Requirements Traceability Matrix

| Allocated Capabilities/Requirements                                             | Traced From Higher-Level Elements                                                                                                                                                                                                                               |
|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| F.4.1 - Control & monitor MCOs (Function)                                       | 3.1.6 - Control & Monitor MCO Environment (OriginatingRequirement)<br>3.1 - Functional Requirements (OriginatingRequirement)<br>3.0 - Technical Requirements (OriginatingRequirement)<br>8.3.1.1 - Design MCO Heat Generation Capacity (OriginatingRequirement) |
| F.5 - Waste Processing (Function)                                               | 3.1.8 - Waste Management (OriginatingRequirement)<br>3.1 - Functional Requirements (OriginatingRequirement)<br>3.0 - Technical Requirements (OriginatingRequirement)                                                                                            |
| F.7 - Storage Function (Function)                                               | 3.1.4 - Storage Mode Requirements - (S) (OriginatingRequirement)<br>3.0 - Technical Requirements (OriginatingRequirement)<br>3.1 - Functional Requirements (OriginatingRequirement)                                                                             |
| 2.11.1 - PSE Assumptions Applicable to All DBAs (OriginatingRequirement)        | 2.11 - DBA-Related Assumptions (OriginatingRequirement)                                                                                                                                                                                                         |
| 2.11.2 - PSE Assumptions Specific to Particular DBAs (OriginatingRequirement)   | 2.11 - DBA-Related Assumptions (OriginatingRequirement)                                                                                                                                                                                                         |
| 3.1.4 - Storage Mode Requirements - (S) (OriginatingRequirement)                | 3.0 - Technical Requirements (OriginatingRequirement)<br>3.1 - Functional Requirements (OriginatingRequirement)                                                                                                                                                 |
| 3.4.6 - Design for Testing (OriginatingRequirement)                             | 3.4 - Systems Engineering Design Considerations (OriginatingRequirement)<br>3.0 - Technical Requirements (OriginatingRequirement)                                                                                                                               |
| 3.5 - Provide for future expansion (OriginatingRequirement)                     | 3.0 - Technical Requirements (OriginatingRequirement)                                                                                                                                                                                                           |
| 3.5.1 - Allow future MCO storage capacity augmentation (OriginatingRequirement) | 3.5 - Provide for future expansion (OriginatingRequirement)<br>3.0 - Technical Requirements (OriginatingRequirement)                                                                                                                                            |

# 1 Requirements Traceability Matrix

| Allocated Capabilities/Requirements                                                 | Traced From Higher-Level Elements                                                                                                                                                                        |
|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3.5.2 - Allow future storage of other nuclear materials<br>(OriginatingRequirement) | 3.5 - Provide for future expansion<br>(OriginatingRequirement)<br><br>3.0 - Technical Requirements<br>(OriginatingRequirement)                                                                           |
| 3.5.3 - Allow future remote equipment<br>(OriginatingRequirement)                   | 3.5 - Provide for future expansion<br>(OriginatingRequirement)<br><br>3.0 - Technical Requirements<br>(OriginatingRequirement)                                                                           |
| 0.1 - Shipment Receipt Rate (PerformanceIndex)                                      | 3.1.1 - Empty - MCO(0) - Receipt & Handling<br>(OriginatingRequirement)<br><br>3.1 - Functional Requirements<br>(OriginatingRequirement)<br><br>3.0 - Technical Requirements<br>(OriginatingRequirement) |
| 0.2 - Empty MCO handling time (PerformanceIndex)                                    |                                                                                                                                                                                                          |

## 7 Functional Behavior Models

### F.2.1.3 Receive empty MCOs

Description:

- a. Conveyance access to the site by means of a new spur connected to the Hanford Site rail system, and a new road connected to the Hanford Site roadway system.
- b. Keep 1 conveyance in standby at any time.
- c. Move the conveyance within the site.
- d. Arrive the conveyance at the facilities involved in the receiving and handling of empty MCO shipments.
- e. Unload the empty MCO (or MCO overpack) off the conveyance and position it on the receiving area.
- f. Move the empty MCO (or MCO overpack) and place it in lag-storage.
- g. Lag-store empty MCOs and MCO overpacks.
- h. Dispatch the conveyance from the SNF CSB facilities.

Duration 8 hours

Allocated To:

- A.10 New MCO Handling Area
- S.1 Canister Storage Building System

Exhibits Performance Objectives:

- Shipment Receipt Rate
- Empty MCO handling time

Inputs:

- MCO(0) shipment
- Source: Function*
- F.2.1.3.3 Receipt inspect new MCO(0)'s

Outputs:

- MCO(0)
- Destination: Function*
- F.2.1.3.7 Place the MCO(0) in lag-storage
- F.2.1.3.8 Move the MCO(0) from lag-storage to transporter/cask

Traced From:

- OriginatingRequirement: 3.1.1.1 Receipt & Handling of Empty MCOs
- OriginatingRequirement: 3.1.2 Empty - MCO(0) - Receipt & Handling

Decomposes Higher-Level Function:

- F.2 Staging Function

## 7 Functional Behavior Models

Decomposed Into Lower-Level Function(s):

- F.2.1.3.1 Receive the conveyance
- F.2.1.3.2 Standby 1 conveyance
- F.2.1.3.3 Receipt inspect new MCO(0)'s
- F.2.1.3.4 Move the conveyance within the site
- F.2.1.3.5 Unload MCO(0) off the conveyance
- F.2.1.3.6 Dispatch the conveyance
- F.2.1.3.7 Place the MCO(0) in lag-storage
- F.2.1.3.8 Move the MCO(0) from lag-storage to transporter/cask
- F.2.1.3.9 Ship MCO(0) to K-Basin

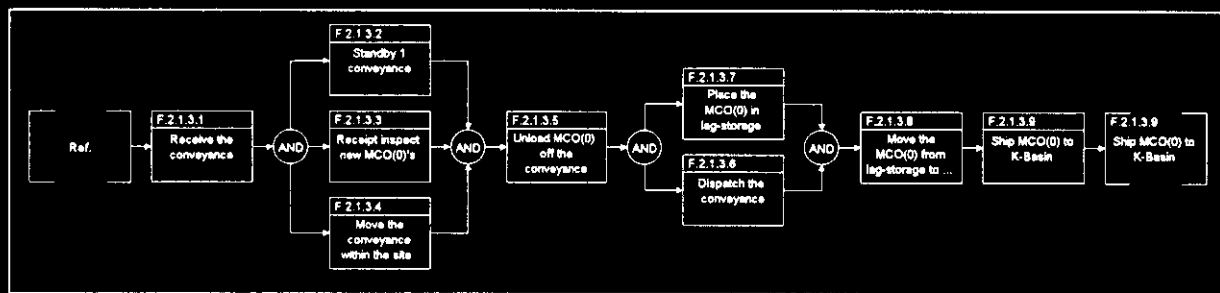


Figure 24 - Receive empty MCOs (Functional Flow Block Diagram)

## 7 Functional Behavior Models

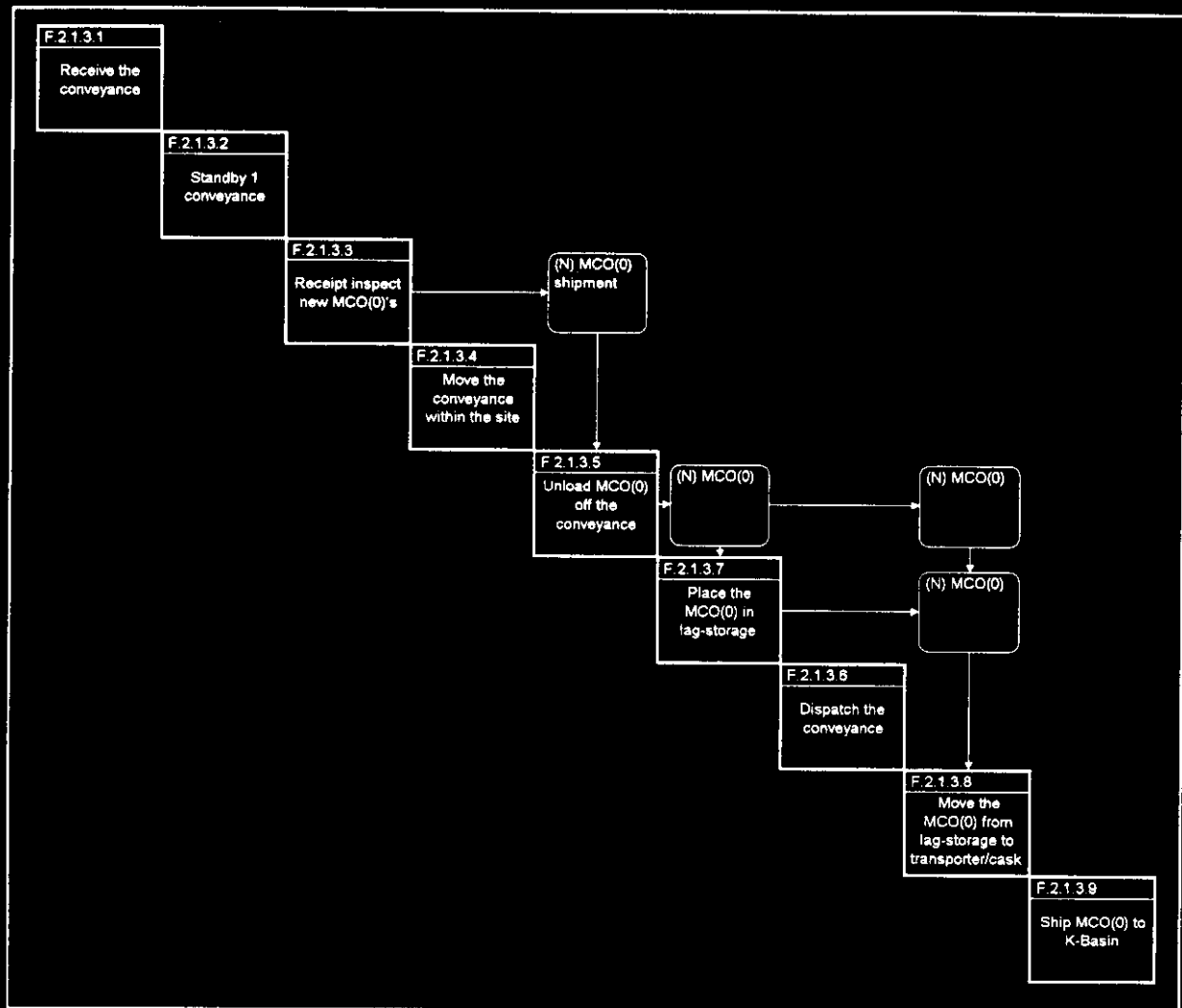


Figure 25 - Receive empty MCOs (N2 Diagram)

### F.2.1.3.1 Receive the conveyance

Allocated To:

A.3 Cask Load-in/load-out Area Structure

Decomposes Higher-Level Function:

F.2.1.3 Receive empty MCOs

### F.2.1.3.2 Standby 1 conveyance

Allocated To:

A.14 Exterior Area

## 7 Functional Behavior Models

---

Decomposes Higher-Level Function:

F.2.1.3 Receive empty MCOs

### F.2.1.3.3 Receipt inspect new MCO(0)'s

Allocated To:

A.10 New MCO Handling Area

Outputs:

MCO(0) shipment

*Destination: Function*

F.2.1.3 Receive empty MCOs

F.2.1.3.5 Unload MCO(0) off the conveyance

Decomposes Higher-Level Function:

F.2.1.3 Receive empty MCOs

### F.2.1.3.4 Move the conveyance within the site

Decomposes Higher-Level Function:

F.2.1.3 Receive empty MCOs

### F.2.1.3.5 Unload MCO(0) off the conveyance

Completion Criterion:

MCO(0) Conveyance emptied

Allocated To:

A.3 Cask Load-in/load-out Area Structure

Inputs:

MCO(0) shipment

*Source: Function*

F.2.1.3.3 Receipt inspect new MCO(0)'s

Outputs:

MCO(0)

*Destination: Function*

F.2.1.3.7 Place the MCO(0) in lag-storage

F.2.1.3.8 Move the MCO(0) from lag-storage to transporter/cask

Decomposes Higher-Level Function:

F.2.1.3 Receive empty MCOs

## 7 Functional Behavior Models

---

### F.2.1.3.6 Dispatch the conveyance

Decomposes Higher-Level Function:

F.2.1.3 Receive empty MCOs

### F.2.1.3.7 Place the MCO(0) in lag-storage

Inputs:

MCO(0)

*Source: Function*

F.2.1.3 Receive empty MCOs

F.2.1.3.5 Unload MCO(0) off the conveyance

F.2.1.3.7 Place the MCO(0) in lag-storage

Outputs:

MCO(0)

*Destination: Function*

F.2.1.3.7 Place the MCO(0) in lag-storage

F.2.1.3.8 Move the MCO(0) from lag-storage to transporter/cask

Decomposes Higher-Level Function:

F.2.1.3 Receive empty MCOs

### F.2.1.3.8 Move the MCO(0) from lag-storage to transporter/cask

Inputs:

MCO(0)

*Source: Function*

F.2.1.3 Receive empty MCOs

F.2.1.3.5 Unload MCO(0) off the conveyance

F.2.1.3.7 Place the MCO(0) in lag-storage

Decomposes Higher-Level Function:

F.2.1.3 Receive empty MCOs

### F.2.1.3.9 Ship MCO(0) to K-Basin

Description:

The empty new MCO is loaded into the shipping cask, for transfer back to K-Basin. This step includes reattachment of the inflatable seal between the MCO(0) and the cask.

Allocated To:

A.10 New MCO Handling Area

S.1.1 MCO Handling System



## 7 Functional Behavior Models

### F.5 Waste Processing

**Description:**

The means to contain, collect, characterize, classify, treat, store, and dispose of the solid, liquid, and effluent waste generated by operations throughout the life of the facility;

**Priority:** 2

**Allocated To:**

A.12 Waste Handling Area

S.1 Canister Storage Building System

**Source Document(s):**

WHC SSF Performance Specification

**Traced From:**

OriginatingRequirement: 3.1.5 Waste Management

**Generates Critical Issue(s):**

CriticalIssue: 2 Solid (LLW) waste disposition not specified

CriticalIssue: 3 Waste Volumes not documented

**Decomposed Into Lower-Level Function(s):**

F.5.1 Collect Solid waste

F.5.2 Collect Liquid Waste

F.5.3 Collect Gaseous Effluent Waste

F.5.4 Characterizes waste.

F.5.5 Classifies waste.

F.5.6 Treat waste

F.5.7 Stores waste

F.5.8 Disposition Waste



**Figure 28 - Waste Processing (Functional Flow Block Diagram)**

## 7 Functional Behavior Models

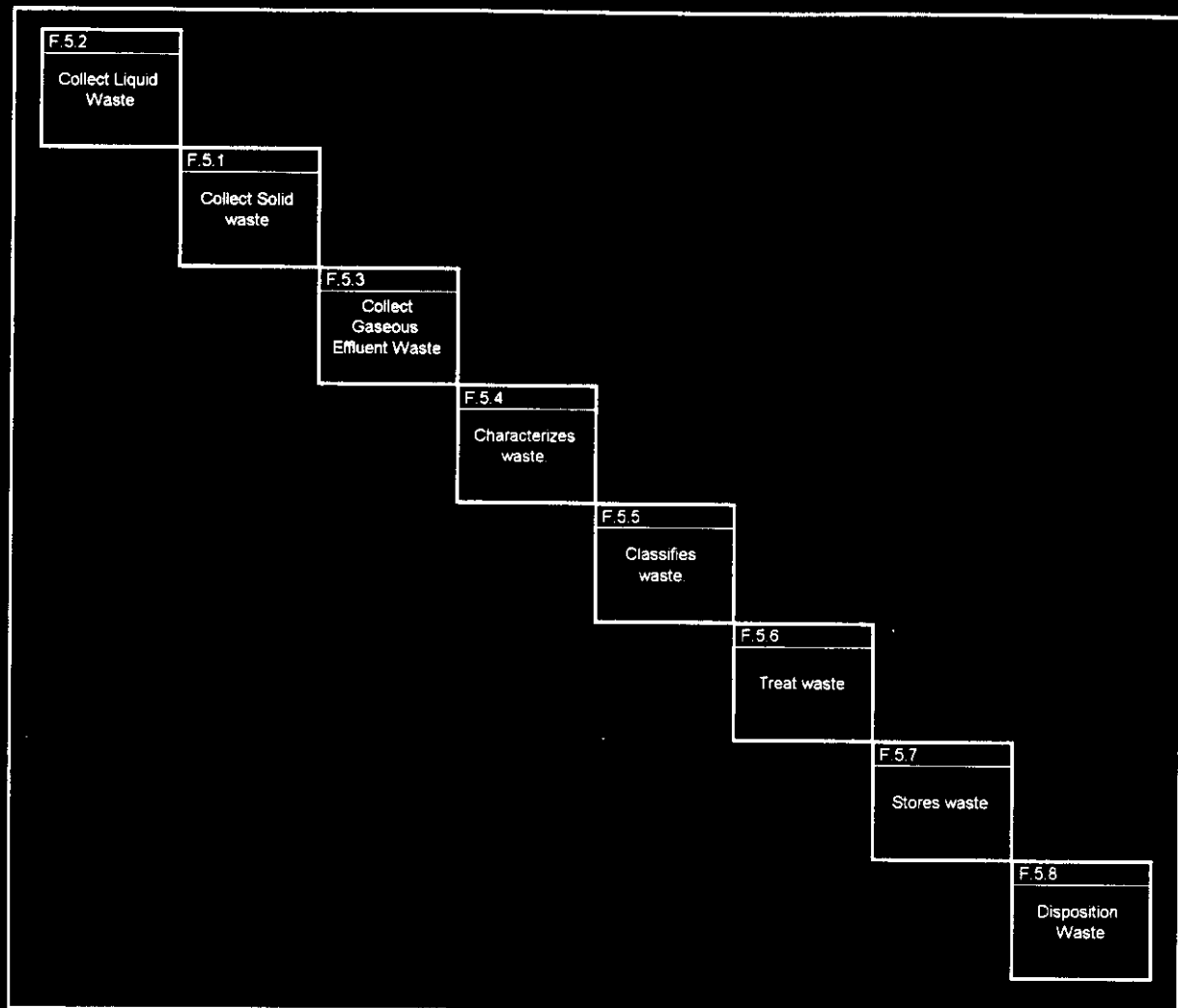


Figure 29 - Waste Processing (N2 Diagram)

### F.5.1 Collect Solid waste

Decomposes Higher-Level Function:

F.5 Waste Processing

### F.5.2 Collect Liquid Waste

Traced From:

Originating Requirement: 8.2.8.2.1 Provide for liquid drains

Decomposes Higher-Level Function:

F.5 Waste Processing

## 7 Functional Behavior Models

---

### F.5.3 Collect Gaseous Effluent Waste

Decomposes Higher-Level Function:

F.5 Waste Processing

### F.5.4 Characterizes waste.

Description:

The CSB characterizes any solid, liquid, and gaseous effluent waste throughout the staging and storage operations

Source Document(s):

WHC SSF Performance Specification

Decomposes Higher-Level Function:

F.5 Waste Processing

### F.5.5 Classifies waste.

Description:

The CSB classifies any solid, liquid, and gaseous effluent waste throughout the staging and storage operations

Source Document(s):

WHC SSF Performance Specification

Decomposes Higher-Level Function:

F.5 Waste Processing

### F.5.6 Treat waste

Description:

The CSB treats any solid, liquid, and gaseous effluent waste throughout the staging and storage operations

Source Document(s):

WHC SSF Performance Specification

Decomposes Higher-Level Function:

F.5 Waste Processing

### F.5.7 Stores waste

Description:

The CSB stores any solid, liquid, and gaseous effluent waste throughout the staging and storage operations

## 7 Functional Behavior Models

---

Source Document(s):

WHC SSF Performance Specification

Decomposes Higher-Level Function:

F.5 Waste Processing

### F.5.8 Disposition Waste

Completion Criterion:

LLW shipped to Treatment Facility or burial site

Allocated To:

S.1.8 Waste Processing System

Inputs:

Low Level Waste (LLW)

*Source: Function*

F.2.1.2.4 Decon transporter/cask

Generates Critical Issue(s):

Critical Issue: 3 Waste Volumes not documented

Causes Risk(s):

9 Waste Treatment facilities may require redesign

Decomposes Higher-Level Function:

F.5 Waste Processing

## 7 Functional Behavior Models

### F.7 Storage Function

**Description:**

In the interim storage mode of operations the SNF CSB receives MCOs containing processed SNF, provides interim storage of the MCOs until their final disposition has been determined and the long-term repository is available, and stages the MCOs for transfer to final disposition.

Duration 40 years

**Allocated To:**

S.1 Canister Storage Building System

**Traced From:**

Originating Requirement: 3.1.4 Storage Mode Requirements - (S)

**Causes Risk(s):**

1 Geologic Repository Requirements not be Available

**Decomposed Into Lower-Level Function(s):**

F.7.1 Receive MCO(S)s from Stabilization Facility

F.7.2 Reconfigure MCO for Storage

F.7.3 Place MCO(S) in Storage Tube

F.7.4 Stages MCO(S)s for transfer to final disposition

F.7.5 Dispositions Stabilized SNF

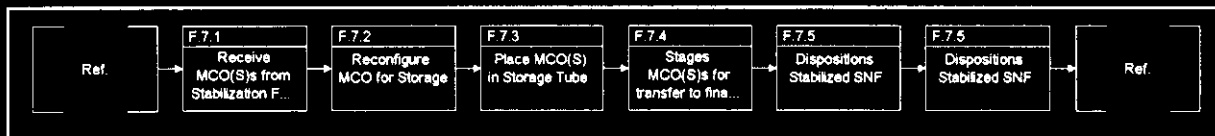


**Figure 30 - Storage Function (Functional Flow Block Diagram)**

## 7 Functional Behavior Models

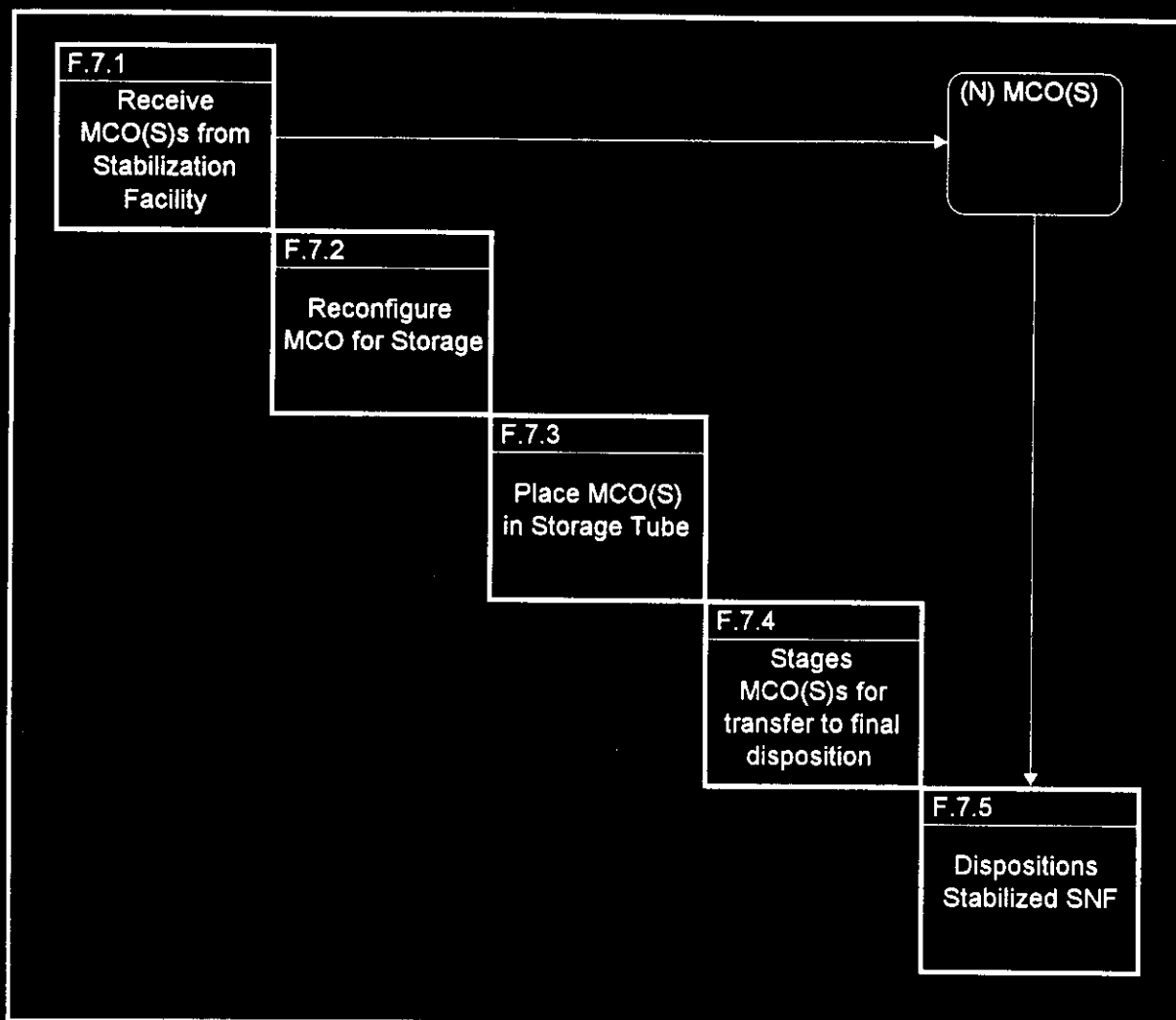


Figure 31 - Storage Function (N2 Diagram)

### F.7.1 Receive MCO(S)s from Stabilization Facility

**Description:**

Handling the MCO (S) for short-term storage starts with receiving the MCO (S) from stabilization and ends when the MCO (S) is configured for interim storage.

Duration 6 hours

**Completion Criterion:**

All SNF passivated, and no MCO(K)s remain at CSB

**Allocated To:**

A.1 Storage Vault Structure

A.2 Operating Deck Area Structure

## 7 Functional Behavior Models

---

### A.3 Cask Load-in/load-out Area Structure

#### S.1.1 MCO Handling System

##### Inputs:

MCO(S)

*Source: Function*

F.7.1 Receive MCO(S)s from Stabilization Facility

##### Outputs:

MCO(S)

*Destination: Function*

F.7.1 Receive MCO(S)s from Stabilization Facility

F.7.5 Dispositions Stabilized SNF

##### Causes Risk(s):

5 Link between CSB and SF is undefined

##### Decomposes Higher-Level Function:

F.7 Storage Function

### F.7.2 Reconfigure MCO for Storage

##### Decomposes Higher-Level Function:

F.7 Storage Function

### F.7.3 Place MCO(S) in Storage Tube

##### Decomposes Higher-Level Function:

F.7 Storage Function

### F.7.4 Stages MCO(S)s for transfer to final disposition

##### Description:

The CSB stages the MCOs of stabilized SNF for transfer to final disposition

##### Source Document(s):

WHC SSF Performance Specification

##### Outputs:

SNF in approved Repository Form (MPC for CRWMS)

##### Decomposes Higher-Level Function:

F.7 Storage Function

## 7 Functional Behavior Models

---

### F.7.5 Dispositions Stabilized SNF

Description:

The CSB disposes the SNF by repackaging it into an acceptable waste form, and shipping it to the geologic repository.

Completion Criterion:

All SNF shipped to geologic repository

Source Document(s):

WHC SSF Performance Specification

Inputs:

MCO(S)

*Source: Function*

F.7.1 Receive MCO(S)s from Stabilization Facility

Outputs:

SNF in approved Repository Form (MPC for CRWMS)

Causes Risk(s):

1 Geologic Repository Requirements not be Available

Decomposes Higher-Level Function:

F.7 Storage Function