OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT SYSTEM DESCRIPTION DOCUMENT COVER SHEET			1. QA: QA Page: 1 of 117
2. SDD Title Waste Emplacement/Retrieval System Description Document			
3. Document Identifier (Including Rev. No. and Change No., if applicable) SDD-WES-SE-000001 REV 01 ICN 01			MOL.20011001.0107
	Printed Name	Signature	Date
4. System Engineer	Eric Loros	E Loros	7/25/01
5. Checker	Neal Pettit	N Pettit	07/25/2001
6. Responsible Manager	Robert Boutin	R. Boutin	07/25/01

7. Remarks:

This document may be affected by technical product input information that requires confirmation. Any changes to the document that may occur as a result of completing the confirmation activities will be reflected in subsequent revisions. The status of the input information quality may be confirmed by review of the Document Input Reference System database.

The following TBDs/TBVs are used in this document:

TBV-241, TBV-245, TBV-248, TBV-253, TBV-254, TBV-274, TBV-336, TBV-345, TBV-1246, TBV-3935, TBV-4655

TBD-179, TBD-181, TBD-257, TBD-330, TBD-331, TBD-389, TBD-395, TBD-405, TBD-406, TBD-409, TBD-429, TBD-3936, TBD-3937

1. SDD Title	
Waste Emplacement/Retrieval System Description Document	
2. Document Identifier (Including Rev. No. and Change No., if applicable)	
SDD-WES-SE-000001 REV 01 ICN 01C	
3. Revision	4. Description of Revision
00	Initial Issue. This document was previously issued using document identifiers BCA000000-01717-1705-00017 and BCA000000-01717-1705-00018. This document supersedes the previous issuances. This document is a complete rewrite of the superseded documents, driven largely by the use of an alternate source of regulatory requirements, the implementation of the License Application Design Selection effort, the use of a new document development procedure, and the combination of the waste emplacement and waste retrieval systems into a single system.
01	This revision updates Section 1 for references that have changed, deletes the contents of Section 1.4 as directed by management, and adds Section 2.
ICN 01	The purpose of this ICN is to incorporate changes contained in Revision 02 ICN 02 of the "Monitored Geologic Repository Project Description Document" to primarily support the Flexible Operations Concept. All changes in the document that have been made as a result of this ICN are indicated by revision bars. Minor editorial changes have also been made, as needed.

CONTENTS

Page

SUMMARY ... 7

QUALITY ASSURANCE ... 9

1. SYSTEM FUNCTIONS AND DESIGN CRITERIA ... 10
   1.1 SYSTEM FUNCTIONS ... 10
   1.2 SYSTEM DESIGN CRITERIA ... 11
   1.3 SUBSYSTEM DESIGN CRITERIA ... 24
   1.4 CONFORMANCE VERIFICATION ... 24

2. DESIGN DESCRIPTION ... 25
   2.1 SYSTEM DESIGN SUMMARY ... 25
   2.2 DESIGN ASSUMPTIONS ... 26
   2.3 DETAILED DESIGN DESCRIPTION ... 29
   2.4 COMPONENT DESCRIPTION ... 45
   2.5 CRITERIA COMPLIANCE ... 60

3. SYSTEM OPERATIONS ... 64

4. SYSTEM MAINTENANCE ... 65

APPENDIX A CRITERION BASIS STATEMENTS ... 66

APPENDIX B ARCHITECTURE AND CLASSIFICATION ... 100

APPENDIX C ACRONYMS, SYMBOLS, AND UNITS ... 101

APPENDIX D FUTURE REVISION RECOMMENDATIONS AND ISSUES ... 102

APPENDIX E MONITORING AND CONTROL SYSTEM INPUT/OUTPUT LISTS ... 103

APPENDIX F TRANSPORTER AND LOCOMOTIVE SAFETY EVALUATIONS ... 108

APPENDIX G REFERENCES ... 111

TABLES

Page

1. Waste Form Temperature Limits 13
2. Heat Flux vs. Temperature 14
3. Maximum WP Lift Heights 15
4. WHB Temperature Environment 17
5. WHB Humidity Environment 18
6. Surface External Relative Humidity Environment 18
7. Precipitation (Rainfall) 18
8. Rail Interface 19
9. Subsurface Waste Emplacement Transportation System Curvatures 19
10. Physical Envelopes 20
11. System Inputs/Outputs 21
12. Waste Package Characteristics 28
13. Criteria Compliance 60
14. System Architecture and QA Classification 100
15. Preliminary Transporter Control System I/O List 103
16. Preliminary Locomotive Control System I/O List 104
17. Preliminary Emplacement Gantry Control System Input/Output List 106
18. Preliminary Emplacement Gantry Carrier Control System Input/Output List 107

FIGURES

1. Site Layout.. 31

2. Locomotives and Waste Package Transporter Approaching the North Portal....................... 34

3. Typical Cross-Section of a Main Drift Showing Waste Package Transportation Equipment 36

4. One Locomotive on Standby while the Other Locomotive Moves the Transporter into the Turnout 38

5. Docked Transporter with Pallet and Waste Package on Transporter's Open Deck and Emplacement Gantry Approaching the Docking Area for Pickup.. 39

6. Equipment and Sequence of Operations for Normal Retrieval 41

7. Emplacement Drift Gantry Carrier and Multi-purpose Hauler 44

8. Operations Monitoring and Control System Interfaces... 46

9. Emplacement Pallet Isometric View 47

10. Emplacement Pallet Loaded with Waste Package... 49

11. Waste Package Transporter and its Components 50

12. Bottom/Side Lift Emplacement Gantry – Perspective View.. 53

13. Bottom/Side Lift Emplacement Gantry – End View within Emplacement Drift................... 56

14. Multi-purpose Hauler Used with Multi-purpose Vehicle for Pallet and Waste Package Retrieval.. 58

15. Gantry Recovery with Emplacement Drift Gantry Carrier 59

SUMMARY

The Waste Emplacement/Retrieval System transports Waste Packages (WPs) from the Waste Handling Building (WHB) to the subsurface area of emplacement, and emplaces the WPs once there. The Waste Emplacement/Retrieval System also, if necessary, removes some or all of the WPs from the underground and transports them to the surface. Lastly, the system is designed to remediate abnormal events involving the portions of the system supporting emplacement or retrieval. During emplacement operations, the system operates on the surface between the WHB and North Portal, and in the subsurface in the North Ramp, access mains, and emplacement drifts. During retrieval or abnormal conditions, the operations areas may also extend to a surface retrieval storage site and South Portal on the surface, and the South Ramp in the subsurface.

A typical transport and emplacement operation involves the following sequence of events. A WP is loaded into a WP transporter at the WHB, and coupled to a pair of transport locomotives. The locomotives transport the WP from the WHB, down the North Ramp, and to the entrance of an emplacement drift. Once docked at the entrance of the emplacement drift, the WP is moved outside of the WP transporter, and engaged by a WP emplacement gantry. The WP emplacement gantry lifts the WP, and transports it to its emplacement location, where the WP is then lowered to its final resting position. The WP emplacement gantry remains in the drift while the WP transporter is returned to the WHB by the locomotives. When the transporter reaches the WHB, the sequence of operations is repeated.

Retrieval of all the WPs, or a large group of WPs, under normal conditions is achieved by reversing the emplacement operations. Retrieval of a small set of WPs, under normal or abnormal conditions, is known as recovery. Recovery performed under abnormal conditions will involve a suite of specialized equipment designed to perform a variety of tasks to enable the recovery process. Recovery after abnormal events may require clearing of equipment, rock, and ground support to facilitate recovery operations. Stabilization of existing ground support and installation of new ground support may also be needed. Recovery of WP(s) after an event that has contaminated drifts and/or WPs will require limiting the spread of contamination. Specialized equipment will also be necessary for system restoration (e.g., after a derailment, component failure.).

The Waste Emplacement/Retrieval System interfaces with the Subsurface Facility System and Ground Control System for the size and layout of the underground openings. The system interfaces with the Subsurface Ventilation System for the emplacement drift operating environment and the size of the drift isolation doors. The system interfaces with all WP types for the size, weight, and other important parameters affecting emplacement, recovery, and retrieval. The system interfaces with the Subsurface Emplacement Transportation System for the rail system upon which it operates and the distribution of power through the rail system. The system interfaces with the Monitored Geologic Repository (MGR) Operations Monitoring and Control System for the transmission of data to and from the system equipment, and for remote control of system equipment. The system interfaces with the Ground Control System for any repairs that are made. The system interfaces with the Emplacement Drift System for the WP emplacement mode and hardware. The system interfaces with the Disposal Container Handling System and

the Waste Handling Building System for the receipt (during emplacement) and delivery (during retrieval/recovery) of WPs.

QUALITY ASSURANCE

The quality assurance (QA) program applies to the development of this document. The ”Technical Work Plan For Subsurface Design Section FY 01 Work Activities” (WP#12112124MI) activity evaluation has determined the development of this document to be subject to “Quality Assurance Requirements and Description” requirements. This document was developed in accordance with AP-3.11Q, “Technical Reports.”

1. SYSTEM FUNCTIONS AND DESIGN CRITERIA

The functions and design requirements for the system are identified in the following sections. Throughout this document the term “system” shall indicate the Waste Emplacement/Retrieval System. Additionally, the term “recovery” is used to indicate selective removal of a small set of WPs from the underground, while the term “retrieval” is used to indicate removal of groups of WPs or the entire inventory of WPs from the underground. The term “restoration” is used to indicate action taken to remediate an abnormal event involving the Waste Emplacement/Retrieval System.

As used in this section, “normal conditions” will refer to a subsurface environment that is performing essentially as expected (e.g., retrieval or recovery after blast cooling of an emplacement drift); “abnormal conditions” will refer to subsurface conditions that have been disturbed in some way (e.g., Waste Emplacement/Retrieval System accident, design basis event occurrence).

The system architecture and classification are provided in Appendix B.

1.1 SYSTEM FUNCTIONS

1.1.1 The system receives WPs at the WHB.

1.1.2 The system transfers WPs to the subsurface repository.

1.1.3 The system emplaces WPs in their final location within emplacement drifts.

1.1.4 The system retrieves to the surface all emplaced WPs or a group of emplaced WPs under normal conditions.

1.1.5 The system recovers to the surface individually selected emplaced WPs under normal and abnormal conditions.

1.1.6 The system clears and removes rock, ground support, failed equipment, and debris impeding retrieval and recovery operations.

1.1.7 The system installs ground support to permit safe conduct of retrieval and recovery operations.

1.1.8 The system limits or prevents the spread of radioactive contamination.

1.1.9 The system supports the collection of material control and accounting data.

1.1.10 The system operates within the surface and subsurface natural and induced environmental conditions expected at the site.

1.1.11 Reserved

1.1.12 The system provides features and equipment for reducing the risk of, responding to, and recovering from, abnormal events and credible design basis events.

1.1.13 The system provides features for the inspection, testing, and maintenance of system equipment.

1.1.14 The system remediates abnormal events involving the portions of the system supporting waste emplacement, retrieval, and recovery.

1.1.15 The system mitigates the effects of a radioactive spill in the subsurface repository.

1.1.16 The system emplaces and recovers "dummy" WPs to support Performance Confirmation operations.

1.2 SYSTEM DESIGN CRITERIA

This section presents the design criteria for the system. Each criterion in this section has a corresponding Criterion Basis Statement in Appendix A that describes the need for the criterion as well as a basis for the performance parameters imposed by the criterion. Each criterion in this section also contains bracketed traces indicating traceability, as applicable, to the functions (F) in Section 1.1, the "Monitored Geologic Repository Requirements Document" (MGR RD), and "Revised Interim Guidance Pending Issuance of New U.S. Nuclear Regulatory Commission (NRC) Regulations (Revision 01, July 22, 1999), for Yucca Mountain, Nevada." In anticipation of the interim guidance being promulgated as a Code of Federal Regulations, it will be referred to as "10 CFR 63" in this system description document. For the applicable version of the codes, standards, and regulatory documents, refer to Appendix G.

1.2.1 System Performance Criteria

1.2.1.1 The system shall maintain operational flexibility to achieve a range of thermal performance by varying the duration of repository operation, ventilation duration, flow rate, and method; WP spacing, WP heat output, and the duration of surface aging.

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5]

1.2.1.2 The portions of the system supporting retrieval, recovery, and restoration shall maintain an operational life of at least 30 years after placement of the final waste package.

[F 1.1.4, 1.1.5, 1.1.16][MGR RD 3.1.C, 3.2.C]

1.2.1.3 The portions of the system supporting retrieval, recovery, and restoration shall include provisions that support a deferral of closure for up to 300 years after initiation of waste emplacement with appropriate maintenance, refurbishment and/or replacement.

[F 1.1.4, 1.1.5, 1.1.16][MGR RD 3.1.C, 3.2.H][10 CFR 63.111(d), 63.111(e)(1), 63.131(b), 63.134(d)]

1.2.1.4 The system shall be capable of transporting and emplacing WPs at the annual throughput (TBD-3936).

[F 1.1.1, 1.1.2, 1.1.3][MGR RD 3.2.C, 3.2.E]

1.2.1.5 The system shall be designed to retrieve all emplaced WPs within 34 years after the initiation of retrieval operations.

[F 1.1.4][MGR RD 3.1.C, 3.2.J][10 CFR 63.111(e)(1), 63.111(e)(3)]

1.2.1.6 The system shall be designed to emplace and retrieve a minimum of 14,870 WPs.

[F 1.1.2, 1.1.3, 1.1.4, 1.1.16][MGR RD 3.1.C, 3.2.C][10 CFR 63.111(e)(1)]

1.2.1.7 The system shall be designed to recover a minimum of (TBD-330) WPs.

[F 1.1.5, 1.1.16][MGR RD 3.1.C][10 CFR 63.111(d), 63.111(e)(1), 63.131(d)(3)]

1.2.1.8 The system shall emplace WPs in emplacement drifts in a horizontal orientation.

[F 1.1.3, 1.1.16]

1.2.1.9 The system shall emplace WPs within each emplacement drift a minimum of 10 cm between the ends of adjacent WPs.

[F 1.1.3]

1.2.1.10 The system shall emplace individual WPs to within (TBD-3937) m of a designated point along the central axis of an emplacement drift.

[F 1.1.3]

1.2.1.11 The system shall be capable of transporting retrieved WPs to the WHB and to a storage area located up to 4 km (2.5 miles) directly north of the WHB (TBV-336).

[F 1.1.4][MGR RD 3.1.C][10 CFR 63.111(e)(1)]

1.2.1.12 The system shall segment debris (e.g., failed ground support materials and rock) into pieces no greater than (TBD-331) mm or (TBD-331) kg.

[F 1.1.5, 1.1.6]

1.2.1.13 The system shall remove debris from the underground up to the maximum sizes of individual pieces of (TBD-331) mm and (TBD-331) kg.

[F 1.1.5, 1.1.6]

1.2.1.14 The system shall be designed to install temporary ground support to facilitate recovery and retrieval operations.

[F 1.1.7][MGR RD 3.1.C][10 CFR 63.111(e)(1)]

1.2.1.15 The system shall be designed to recover WPs from an emplacement drift that has blocked ventilation.

[F 1.1.5, 1.1.10]

1.2.1.16 The system shall be designed to perform recovery while the Subsurface Emplacement Transportation System and the Site Communications System have failed at any location in the underground.

[F 1.1.5]

1.2.1.17 The system shall be capable of performing recovery from either end of an emplacement drift.

[F 1.1.5]

1.2.1.18 The system shall provide means to limit concentration of radioactive material in air during WP transfer from the emplacement drift to the surface.

[F 1.1.5, 1.1.8][MGR RD 3.1.C, 3.1.G][10 CFR 63.112(e)(1)]

1.2.1.19 The system shall ensure that the waste forms remain below the temperatures identified in Table 1 during emplacement, retrieval, recovery, and restoration.

Table 1. Waste Form Temperature Limits

Waste Form	Temperature Limit
Commercial Spent Nuclear Fuel	350ºC (662ºF) (TBV-241)
Vitrified High Level Waste	400ºC (752ºF)
Department of Energy Owned Spent Nuclear Fuel	(TBD-179)
Non-Fuel Components	(TBD-181)

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5][MGR RD 3.2.L]

1.2.1.20 The system shall re-emplace all of the WPs moved (but not themselves targeted to retrieval or recovery) to perform retrieval and recovery operations. Re-emplacement shall be completed prior to repository closure.

[F 1.1.3, 1.1.4, 1.1.5, 1.1.16][MGR RD 3.1.C][10 CFR 63.111(d), 63.131(d)(3)]

1.2.1.21 The system equipment operated in an area with the potential for contamination shall have an appropriate surface finish and geometry to facilitate decontamination and limit the accumulation of fixed contamination.

[F 1.1.8][MGR RD 3.1.G, 3.3.A]

1.2.1.22 The system shall re-rail and restore to normal operation, if practical, any derailed system equipment.

[F 1.1.14][MGR RD 3.1.G]

1.2.1.23 The system shall transport to the surface any system equipment that cannot be re-railed and restored to normal operation.

[F 1.1.14][MGR RD 3.1.G]

1.2.1.24 The system shall be designed to clear debris from a minimum of 12 mm (0.5 in.) in the smallest dimension to a maximum of 534 mm (21 in.) in the largest dimension off of the rail and out of the way of the rail flange in front of rail mounted equipment as the equipment travels on the Subsurface Emplacement Transportation System.

[F 1.1.4, 1.1.5]

1.2.1.25 The system shall be designed to decontaminate underground openings to below the levels given in Section 222 of "Radiological Control Manual," or apply a fixative coating over contaminated surfaces to prevent the spread of contamination. (TBV-345)

[F 1.1.15]

1.2.1.26 The system shall ensure that the heat fluxes on the surface of the Naval SNF canister equal or exceed the values identified in Table 2 during emplacement, retrieval, recovery, and restoration.

Table 2. Heat Flux vs. Temperature

Temperature (°C)	Heat Flux (kW/m^2)
50	0.600
131	0.535
197	0.491
216	0.224
TBD-429	TBD-429

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5][MGR RD 3.2.L]

1.2.2 Safety Criteria

1.2.2.1 Nuclear Safety Criteria

1.2.2.1.1 The system shall ensure that an uncontrolled descent down the North or South Ramp of system equipment carrying a WP is limited to less than 1 x 10^{-6} events/year.

[F 1.1.12][MGR RD 3.1.C][10 CFR 63.111(a)(2), 63.111(b)(2), 63.112(e)(8)]

1.2.2.1.2 The system maximum speed shall be 8 km/hr.

[F 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.12][MGR RD 3.1.C][10 CFR 63.111(a)(2), 63.111(b)(2), 63.112(e)(8)]

1.2.2.1.3 The system shall lift the WP no higher than the maximum lift heights specified in Table 3. (TBV-245)

Table 3. Maximum WP Lift Heights

WP Lift	Maximum Lift Height
WP in a Vertical Orientation	2 m (6.6 ft) TBV
WP in a Horizontal Orientation	2.4 m (7.9 ft) TBV

[F 1.1.12][MGR RD 3.1.C][10 CFR 63.111(a)(2), 63.111(b)(2), 63.112(e)(8)]

1.2.2.1.4 The system shall provide features to recover from abnormal and/or design basis events, including backup measures to place and release loads in a safe manner.

[F 1.1.12][MGR RD 3.1.C, 3.1.G][10 CFR 63.111(a)(2), 63.111(b)(2), 63.112(e)(8)]

1.2.2.1.5 The structures, systems, and components (SSCs) important to safety shall be designed to permit prompt termination of operations and maintain WPs in a safe and sustainable position during an emergency.

[F 1.1.12][MGR RD 3.1.C, 3.1.G][10 CFR 63.112(e)(10)]

1.2.2.1.6 The system shall be designed to retain suspended loads during and after a Frequency Category 1 (TBV-1246) design basis earthquake.

[F 1.1.12][MGR RD 3.1.C, 3.1.G][10 CFR 63.111(a)(2), 63.111(b)(2), 63.112(e)(8)]

1.2.2.1.7 The system shall be designed to retain suspended loads during and after a loss of electrical power.

[F 1.1.12][MGR RD 3.1.C][10 CFR 63.111(a)(2), 63.111(b)(2), 63.112(e)(8)]

1.2.2.1.8 The system shall be designed to retain the WP inside the WP transporter during credible design basis events.

[F 1.1.12][MGR RD 3.1.C, 3.1.G][10 CFR 63.112(e)(10)]

1.2.2.1.9 The system shall be designed in accordance with the project ALARA (as low as is reasonably achievable) program goals (TBD-406) and the applicable guidelines in "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low as is Reasonably Achievable" (Regulatory Guide 8.8).

[MGR RD 3.1.B, 3.1.C, 3.1.G][10 CFR 63.111(a)(1)]

1.2.2.1.10 The system shall limit the use of diesel-powered equipment to less than the amount identified in a Site Performance Protection Analysis.

[F 1.1.5, 1.1.10, 1.1.12, 1.1.14]

1.2.2.2 Non-Nuclear Safety Criteria

1.2.2.2.1 The system shall provide features to ensure Performance Confirmation "dummy" WPs are disconnected from all instrument leads and power sources prior to recovery.

[F 1.1.5, 1.1.16]

1.2.3 System Environment Criteria

1.2.3.1 The system shall be designed such that components susceptible to radiation can withstand and operate in the radiation environment (TBD-405) in which the component is located.

[F 1.1.10][MGR RD 3.3.A]

1.2.3.2 The system components shall be designed to withstand and operate in the WHB temperature environment defined in Table 4 for the area in which the component is located.

Table 4. WHB Temperature Environment

Location of System Component	Normal Environment	Off-Normal Environment
Normally Occupied Areas (e.g., Offices, Maintenance Areas, Access Control)	70 - 78°F	(TBD-395) °F for (TBD-395) Hours
Normally Unoccupied Areas (e.g., Mechanical & Electrical Equipment Rooms, Cask Receiving & Handling Areas, Pool Areas)	63 - 92°F	(TBD-395) °F for (TBD-395) Hours
Unoccupied Areas (e.g., Assembly Cells, Canister Transfer Cells, Disposal Container Handling Cells, Emergency Generator Room)	63 - 106°F	(TBD-395) °F for (TBD-395) Hours
Electronics Equipment Areas (e.g., Control Rooms, Computer Rooms, Communications Equipment Rooms, Data Processing and Recording Equipment Rooms)	70 - 74°F Note 1	70 - 74°F Note 1

Note 1: It is intended to maintain these areas at the specified temperature under all anticipated conditions. However, due to economic or design impracticability, areas that house less sensitive electronic components may not be maintained at this temperature. For these components, cooling would be provided for the electronic components, but not necessarily the entire area.

[F 1.1.10][MGR RD 3.3.A]

1.2.3.3 The system shall be designed to withstand and operate in the extreme outside temperature environment of -15 degrees C to 47 degrees C.

[F 1.1.10][MGR RD 3.3.A]

1.2.3.4 The system shall be designed to withstand and operate in the extreme subsurface temperature environment of 7 degrees C (TBV-3935) to 50 degrees C.

[F 1.1.10][MGR RD 3.3.A]

1.2.3.5 The system components shall be designed to withstand and operate in the WHB humidity environment defined in Table 5, for the area in which the component is located.

Table 5. WHB Humidity Environment

Location of System Component	Normal Environment
Normally Occupied Areas (e.g., Offices, Maintenance Areas, Access Control)	30% - 60%
Normally Unoccupied Areas (e.g., Mechanical & Electrical Equipment Rooms, Cask Receiving & Handling Areas, Pool Areas)	Humidity Not Controlled (TBD-409) Note 1
Unoccupied Areas (e.g., Assembly Cells, Canister Transfer Cells, Disposal Container Handling Cells, Emergency Generator Room)	Humidity Not Controlled (TBD-409) Note 1
Electronics Equipment Areas (e.g., Control Rooms, Computer Rooms, Communications Equipment Rooms, Data Processing and Recording Equipment Rooms)	40% - 50%

Note 1: Humidity control is not provided in most of these areas. Therefore, components susceptible to extreme humidity conditions must be evaluated for low and/or high humidity environments since special provisions (e.g., heater strips, humidifier) may be necessary.

[F 1.1.10][MGR RD 3.3.A]

1.2.3.6 The system shall be designed to withstand and operate in the surface external relative humidity environment described in Table 6.

Table 6. Surface External Relative Humidity Environment

Parameter	Value
Annual mean value	28%
Minimum summer mean value (June)	13%
Maximum winter mean value (December)	46%

[F 1.1.10][MGR RD 3.3.A]

1.2.3.7 The system shall be designed to withstand and operate in the subsurface relative humidity environment (TBD-389).

[F 1.1.10][MGR RD 3.3.A]

1.2.3.8 The system shall be designed to withstand and operate in the precipitation environment described in Table 7.

Table 7. Precipitation (Rainfall)

Parameter	Range/Maximum
Maximum annual precipitation	25 cm/yr (10 in./yr)
Maximum daily precipitation	13 cm/day (5 in./day)

[F 1.1.10][MGR RD 3.3.A]

1.2.3.9 The Waste Package Transporter and Locomotives shall be designed for a maximum wind speed of 54.1-m per second (121-miles per hour).

[F 1.1.10][MGR RD 3.3.A]

1.2.4 System Interfacing Criteria

1.2.4.1 The system shall operate within the surface facilities' physical envelopes of (TBD-257).

[F 1.1.1, 1.1.2, 1.1.4, 1.1.5, 1.1.14]

1.2.4.2 Reserved

1.2.4.3 The portions of the system supporting emplacement shall operate over a maximum grade of ±2.5 percent outside of emplacement drifts and a maximum grade of ±1 percent within the emplacement drifts.

[F 1.1.1, 1.1.2, 1.1.3]

1.2.4.4 The portions of the system supporting retrieval, recovery, and restoration shall operate over a maximum grade of ±2.7 percent outside of emplacement drifts and a maximum grade of ±1 percent within the emplacement drifts.

[F 1.1.4, 1.1.5, 1.1.14]

1.2.4.5 The system shall operate, where practical, on the track provided by the Subsurface Emplacement Transportation System as identified in Table 8.

Table 8. Rail Interface

Area	Rail Interface
Surface Facilities, Ramps, Main Drifts, and Turnouts	1.44 m (56 1/2 in.) gage (TBV-274)
Emplacement Drifts	2.95 m (116 in.) rail center to center spacing (TBV-274)

[F 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14]

1.2.4.6 The system shall operate within the Subsurface Emplacement Transportation System curvatures identified in Table 9. (TBV-253)

Table 9. Subsurface Waste Emplacement Transportation System Curvatures

Location	Minimum Radius
Ramps and Mains	305 m (TBV)
On the Surface and Within Emplacement Drift Turnouts	20 m (TBV)

[F 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14]

1.2.4.7 The system shall accommodate a minimum 0.80-m (TBV-254) difference in elevation between the bottom of the turnout and the bottom of the emplacement drift.

[F 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14]

1.2.4.8 The system shall emplace and retrieve WPs from emplacement drifts having a maximum length of 700 m.

[F 1.1.3, 1.1.4]

1.2.4.9 The system shall be capable of restoring portions of the system located in, and recovering WPs from, emplacement drifts via the adjoining emplacement drift, with each drift having a maximum length of 700 m.

[F 1.1.5, 1.1.14]

1.2.4.10 The system shall operate within the Ground Control System physical envelopes including clearance provisions for other subsurface system equipment placed in the underground openings as defined in Table 10.

Table 10. Physical Envelopes

Subsurface Area	Physical Envelope for the Waste Emplacement System
Main Drifts and Ramps	Equipment Height: 5.60 m (TBV-253) Equipment Width: 3.55 m (TBV-253)
Emplacement Drifts	Equipment Height: 3.58 m (TBV-253) Equipment Width: 3.55 m (TBV-253)
Drift Turnouts	Equipment Height: 5.60 m (TBV-253) Equipment Width: 6.15 m (TBV-253)

Note: A clearance distance of 100mm is to be added to physical envelopes listed in Table 10.

[F 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14]

1.2.4.11 The system shall receive electrical power from the Subsurface Emplacement Transportation System.

[F 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14]

1.2.4.12 The system shall operate with an electrical power feed provided by the Subsurface Emplacement Transportation System at both ends of an emplacement drift.

[F 1.1.4, 1.1.5, 1.1.14]

1.2.4.13 The system shall receive and provide the operational information, status, and control data defined in Table 11 to the MGR Operations Monitoring and Control System.

Table 11. System Inputs/Outputs

Inputs	Outputs
Radiation monitoring data and status	Equipment status and status of operations
Subsurface Electrical Distribution System data and status monitoring	Equipment alarm status
Subsurface Fire Suppression System data and status monitoring	Control equipment status and alarms
WP identification and tracking data	Interlock status
Operational message advisory	Video signals
Activity plans and procedures	Communications equipment status
Emergency response commands	Timeout warnings for handling equipment
MGR operational alarm status	Control loads left in improper states (suspended loads, unattended controls, etc.)
Remote Control of System Equipment	

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14][MGR RD 3.1.C, 3.2.C, 3.2.E, 3.3.K][10 CFR 63.111(a)(2), 63.111(b)(2), 63.112(e)(8)]

1.2.4.14 Reserved

1.2.4.15 The system shall accommodate a WP maximum surface dose rate of 1450 rem/hr (TBV-248).

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.16]

1.2.4.16 The system shall accommodate a maximum WP thermal output of 11.8 kW.

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.16]

1.2.4.17 The system shall limit dynamic and handling loads to within the design limits of the WPs, facilities, and support systems.

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14][MGR RD 3.3.A, 3.4.2.C]

1.2.4.18 The system equipment operating in the emplacement drift shall pass through the emplacement drift isolation doors to each emplacement drift.

[F 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14]

1.2.4.19 The system shall provide features to obtain the WP unique identifiers and emplacement locations for data input into Safeguards and Security System.

[F 1.1.9][MGR RD 3.1.C, 3.1.D, 3.3.K][10 CFR 63.78]

1.2.5 Operational Criteria

1.2.5.1 The system shall include provisions for the inspection, testing, and maintenance of system equipment.

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.13, 1.1.14][MGR RD 3.1.C, 3.1.G, 3.3.A][10 CFR 63.112(e)(13)]

1.2.5.2 The inherent availability for the system shall be greater than 0.9485 (TBV-4655).

[F 1.1.1, 1.1.2, 1.1.3][MGR RD 3.3.A]

1.2.6 Codes and Standards Criteria

1.2.6.1 The system shall comply with the applicable provisions of “Standards for Protection Against Radiation” (10 CFR 20).

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14][MGR RD 3.1.B]

1.2.6.2 The system shall comply with the applicable provisions of “Occupational Safety and Health Standards” (29 CFR 1910).

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14][MGR RD 3.1.E]

1.2.6.3 Design of steel structural members shall be in accordance with “Manual of Steel Construction, Allowable Stress Design.”

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14][MGR RD 3.1.G]

1.2.6.4 The system designs shall be in accordance with the applicable requirements from Sections 5.2, 5.6, 6.2, and 6.6 of “American National Standard Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants” (ANSI/ANS-57.2-1983).

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14][MGR RD 3.1.G]

1.2.6.5 The system designs shall be in accordance with the applicable requirements from Sections 5.1.1, 5.1.5, 5.8, 5.11, 6.1.1, 6.1.5, 6.8, and 6.11 of "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)" (ANSI/ANS-57.9-1992).

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14][MGR RD 3.1.G]

1.2.6.6 The system shall be designed in accordance with Section 4 of "American National Standard for Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 Kg) or More" (ANSI N14.6-1993).

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14][MGR RD 3.1.G]

1.2.6.7 The system designs shall be in accordance with Sections 1 and 2 of "Structural Welding Code - Steel" (ANSI/AWS D1.1:1998).

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14][MGR RD 3.1.G]

1.2.6.8 Construction of overhead and gantry cranes shall be in accordance with "Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)" (ASME NOG-1-1995).

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14][MGR RD 3.1.G]

1.2.6.9 The system designs shall be in accordance with "Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes" (CMAA-70-94).

[F 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.14][MGR RD 3.1.G]

1.2.6.10 Reserved

1.2.6.11 The system shall be designed in accordance with the applicable sections of the "National Electrical Code" (NFPA 70).

[MGR RD 3.3.A]

1.2.6.12 The system shall comply with the applicable assumptions contained in the "Monitored Geologic Repository Project Description Document."

1.2.6.13 The system shall comply with the applicable provisions of "Safety and Health Regulations for Construction" (29 CFR 1926).

[MGR RD 3.1.F]

1.3 SUBSYSTEM DESIGN CRITERIA

There are no subsystem design criteria for this system.

1.4 CONFORMANCE VERIFICATION

This section will be provided in a future revision.

2. DESIGN DESCRIPTION

Section 2 of this document summarizes information that is contained in other references. By assembling system specific information contained elsewhere (i.e., analyses, technical reports, etc.), Section 2 provides insight into the current state of the design of this system. However, due to the nature of design development, the information contained in this section will continue to change as the design matures.

2.1 SYSTEM DESIGN SUMMARY

The principal purpose of the Waste Emplacement/Retrieval System is to receive WPs at the WHB, transport WPs to the subsurface repository on an internal railroad system using a pair of locomotives and a shielded railcar (transporter), and then emplace WPs within drifts (located approximately perpendicular to the access mains) using a remotely operated gantry ("Bottom/Side Lift Gantry Conceptual Design," "Site Recommendation Subsurface Layout," and "Waste Package Transport and Transfer Alternatives").

The emplacement equipment will be designed to emplace approximately 14,870 WPs (14,870 WPs bounds the 97,000 metric tons heavy metal emplacement scenario). The peak emplacement rate is expected to be 605 WPs per year; therefore, adequate capacity is available to emplace all the waste in less than the required time ("Bottom/Side Lift Gantry Conceptual Design," Section 5.8)

Retrievability is the other principal function of the emplacement/retrieval system. It is mandated by the "Nuclear Waste Policy Act of 1982" (42 U.S.C. 10101, Section 122) and requires that the repository be designed and constructed to permit the retrieval of any or all of the emplaced spent nuclear fuel during the preclosure period. Retrieval may be justified under this act for any of the following reasons: public health and safety, environmental concerns, and the recovery of economically valuable constituents of the spent fuel.

Retrieval may take place under normal conditions (i.e., a subsurface environment that is essentially as expected) or abnormal conditions (i.e., an environment where subsurface conditions have been disturbed). In addition, retrieval generally refers to removal of groups of WPs, or even the entire inventory of WPs from the underground repository, only under normal conditions. The term "recovery" is used to indicate removal of a small set of WPs under normal conditions or abnormal conditions, while "restoration" refers to action taken to remediate an abnormal event involving the emplacement/retrieval system.

Retrieval and recovery under normal conditions utilize the same material handling and rail equipment used for emplacement. Operations simply proceed in the reverse order. Recovery under abnormal conditions and restoration require the use of specially designed vehicles and support equipment including a multi-purpose hauler and emplacement drift gantry carrier.

2.2 DESIGN ASSUMPTIONS

Controlled Project Assumptions (CPA) have been developed to help establish design bases for the subsurface repository in support of the Site Recommendation and License Application milestones. Additional assumptions may be developed for specific systems but they may not conflict with a CPA ("Monitored Geologic Repository Project Description Document," Section 1.1).

Both types of assumptions have been utilized in the development of the Waste Emplacement/ Retrieval System design and are summarized below.

2.2.1 Controlled Project Assumptions

The following inputs from the "Monitored Geologic Repository Project Description Document" have been or will be incorporated into the design of the emplacement/retrieval system.

2.2.1.1 Surface Facilities Location

The proposed repository waste handling and administrative surface facilities will be located adjacent to the North Portal ("Monitored Geologic Repository Project Description Document," Section 2.5).

2.2.1.2 Use of North Ramp for Waste Transport

The North Ramp will be used for waste transport ("Monitored Geologic Repository Project Description Document," Section 2.4).

2.2.1.3 ALARA Cost-Benefit Analysis

In evaluating design options to ensure that doses are ALARA, cost-benefit analysis will be conducted when there is a tradeoff between the dose reduction achieved and the added cost to implement the corresponding option. The costs and dose averted are measured over the life of the facility, with costs expressed on a present worth basis ("Monitored Geologic Repository Project Description Document," Section 5.1.2.2).

2.2.1.4 Waste Package Shielding

WP containment barriers will provide sufficient shielding for protection of WP materials from radiation-enhanced corrosion, but will not provide any additional shielding for personnel protection. Additional shielding for personnel protection will be provided on the subsurface and surface waste handling SSCs, including the WP transporter ("Monitored Geologic Repository Project Description Document," Section 5.2.23).

2.2.1.5 Limitation on Human Entry in Emplacement Drifts Containing Waste Packages

Under normal conditions, no human entry is planned in emplacement drifts while WPs are present. The waste emplacement, retrieval, and performance confirmation equipment may use robotics or remote control features to perform operations and monitoring within the emplacement drifts. Under off-normal conditions, human entry will be considered and protection (including radiation) to the workers will be provided ("Monitored Geologic Repository Project Description Document," Section 5.3.2).

2.2.1.6 Underground Transport of Personnel, Supplies, and Excavated Rock

Rail in both the emplacement and development sides of the repository will be used for transporting underground supplies, equipment, and personnel to the extent practical ("Monitored Geologic Repository Project Description Document," Section 2.5). Excavated rock will be removed by conveyor belt or conveyor belt variation when practical ("Monitored Geologic Repository Project Description Document," Section 2.5). Conveyors, however, are not included in the Waste Emplacement/Retrieval System.

2.2.1.7 Diesel Equipment Limitation

The use of diesel-powered equipment will not be allowed in the subsurface repository under normal conditions. Its use is not precluded, however, in off-normal events.

2.2.1.8 Applicability of Mine Safety and Health Administration Regulations

There is no implication that the Mine Safety and Health Administration has any enforcement authority over construction or operations of the subsurface repository. Nevertheless, some regulations that implement the "Federal Mine Safety and Health Act of 1977" (30 U.S.C. 801, et seq.) may be selectively applied as appropriate design criteria for subsurface facilities and equipment, and for mining-related surface facilities and equipment ("Monitored Geologic Repository Project Description Document," CPA 027).

2.2.2 Additional Assumptions

Other assumptions used in this system description document are identified and explained in this section.

2.2.2.1 Distribution of Weight in Waste Packages

The weight of each WP is assumed to be uniformly distributed throughout the volume of the container. The radioactive waste material will be placed in symmetrically oriented basket assemblies, which will result in uniform distribution of weight and a center of gravity located near the center of the package ("Bottom/Side Lift Gantry Conceptual Design," Section 5.1 and "Waste Package Transport and Transfer Alternatives," Section 5.1).

2.2.2.2 Subsurface Seismic Loadings

Vertical and horizontal accelerations due to a seismic event need to be verified to validate the design of the bottom/side lift gantry and other subsurface mobile equipment that handles WPs. Subsurface seismic forces are currently based upon a horizontal motion of 0.242 g and a vertical motion of 0.182 g. Peak ground velocities in the subsurface are 14.73 cm/sec for horizontal motion and 7.55 cm/sec for vertical motion ("Waste Package Transport and Transfer Alternatives," Section 5.2).

2.2.2.3 Surface Seismic Loadings

Because the WP transporter operates on the surface at least part of the time, surface ground motions presented in "Seismic Design Basis Inputs for a High-Level Repository at Yucca Mountain, Nevada" must also be validated. Surface seismic forces for values at the ground surface in the absence of a structure are currently based on a horizontal acceleration of 0.603 g and a vertical acceleration of 0.392 g. Peak ground velocities at the surface are 20.52 cm/sec for horizontal motion and 9.42 cm/sec) for vertical motion ("Waste Package Transport and Transfer Alternatives," Section 5.2).

2.2.2.4 Annual Throughput for the Waste Handling System

An estimated peak emplacement rate of 605 WPs per year is used in the design of the system ("Bottom/Side Lift Gantry Conceptual Design," Section 5.8).

2.2.2.5 Waste Package Characteristics

The system will transport, emplace, and possibly retrieve WPs with the characteristics defined in Table 12 ("Subsurface Transporter Safety Systems Analysis," Section 4.2.3).

Table 12. Waste Package Characteristics

Characteristic	Value
Length	3.700 m to 6.200 m (12.139 ft to 20.341 ft)
Diameter	1.250 m to 2.000 m (4.101 ft to 6.562 ft)
Weight	83,000 kg maximum (182,980 lb)

However, to allow for increases in WP weight without impacting the emplacement and retrieval equipment, a bounding condition of 85,000 kg (187,390 lb) was selected as the maximum design weight of a WP ("Bottom/Side Lift Gantry Conceptual Design," Section 4.2.1; and "Waste Package Transport and Transfer Alternatives," Section 4.2.1).

2.2.2.6 Pallet Characteristics

The system will handle WPs mounted on pallets, with the maximum weight of the pallet bounded at 3,000 kg (6614 lb) ("Bottom/Side Lift Gantry Conceptual Design," Section 6.2; and "Waste Package Transport and Transfer Alternatives," Section 5.8).

2.2.2.7 Physical Layout of North Ramp and North Ramp Curve

The subsurface repository layout is assumed to reflect the current layout of the North Ramp and North Ramp curve ("Exploratory Studies Facility TS North Ramp General Arrangement Plan & Profile"), but the geometric data must be validated ("Subsurface Transporter Safety Systems Analysis," Section 4.1.2). This includes elevations and/or slopes, lengths of tangents, and curve radii and coordinates.

2.2.2.8 Fault Tree Model for Subsurface Transporter Safety Systems

A fault tree model was developed to assist in evaluating transporter safety. It is assumed to be representative of the braking, control, and communications system on a waste handling train consisting of a primary locomotive, a shielded transporter containing a WP, and a secondary locomotive ("Subsurface Transporter Safety Systems Analysis," Section 5.9).

Specific assumptions on trip frequency, on component and operator failure rates, and on probabilities and bounds of common cause failures are detailed in the "Subsurface Transporter Safety Systems Analysis" (Sections 5.9, 5.10, 5.11, and 5.12).

2.3 DETAILED DESIGN DESCRIPTION

2.3.1 Site Layout

The WPs will be transported from surface facilities by rail to an emplacement drift in the subsurface repository. Routing will vary, depending on the drift chosen as the destination for a particular WP. Generally, however, waste emplacement will occur from north to south, lagging behind emplacement drift construction, with WPs emplaced in recently completed drifts as they become available and certified as acceptable for waste emplacement.

Figure 1 shows the overall repository subsurface layout ("Site Recommendation Subsurface Layout," Figure 11) to which a portion of the surface facilities and the rail line connecting the surface and subsurface facilities have been added. The repository features pertinent to the emplacement and retrieval of WPs are identified in the figure as:

1. The WHB, which is part of the surface facilities; this is where the WPs will be transferred to the rail system for transport to the underground repository.

2. The rail line from the WHB to the North Portal.

3. The North Portal, which is one of the two entrances to the repository subsurface facilities.

4. The North Ramp, which is an underground tunnel leading from the North Portal to the east main.

5. The east and west mains, which are the tunnels that provide access to the ends of the emplacement drifts.

6. The North Ramp curve, which is the section of the North Ramp that turns toward the south to meet the east main drift.

7. The North Ramp extension, which is the tunnel that extends from the North Ramp (above the curve) toward the north to meet the east main.

8. The north main, which is the loop that connects the east main to the west main at the north end of the repository block.

9. The south main, which is the loop that connects the east main to the west main at the south end of the repository block.

10. Emplacement drift turnouts, which are the curved sections of drift connecting each end of an emplacement drift to the main drifts. The turnout approach from the main drifts is always from the south at both the east and west sides of the repository block.

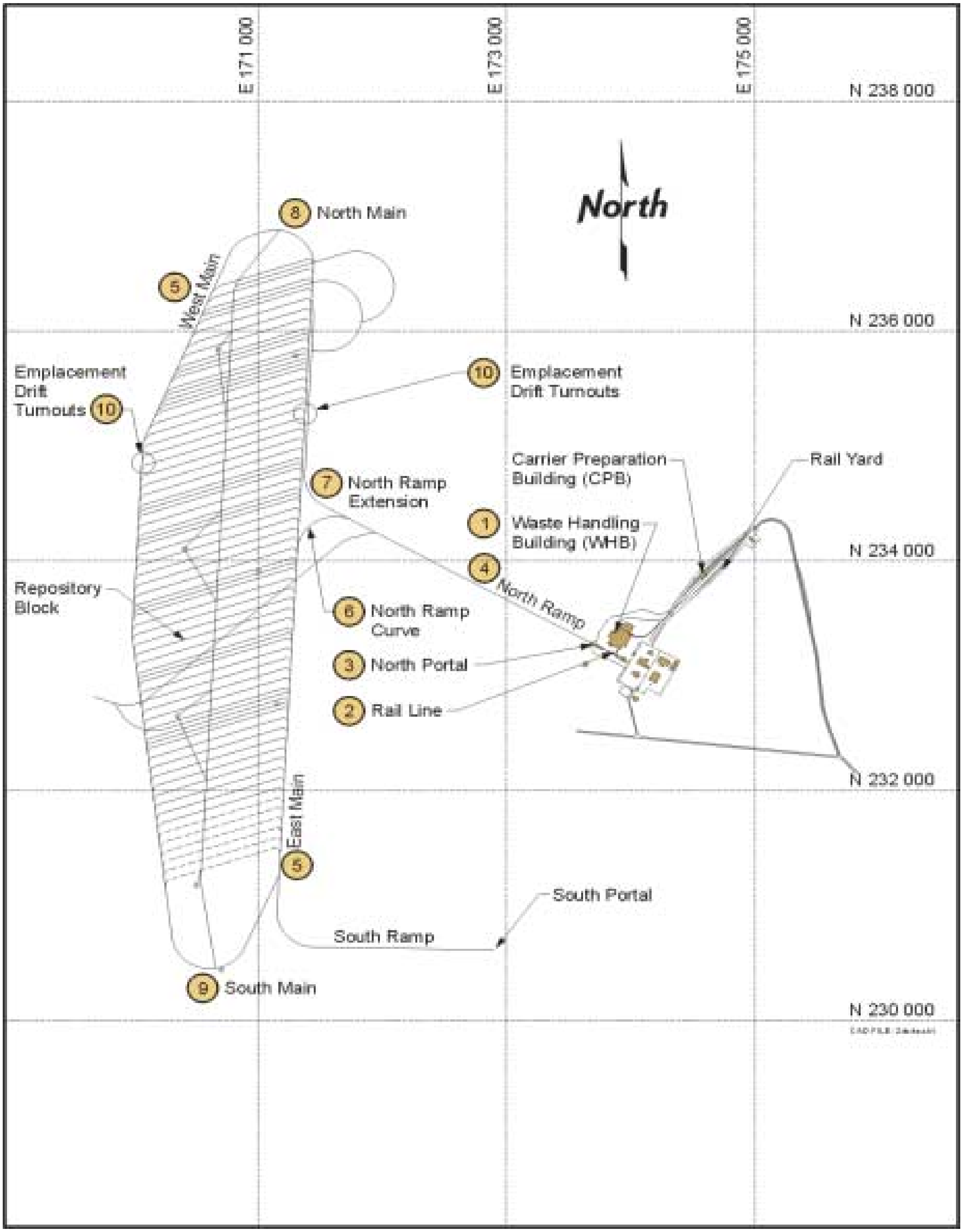

Figure 1. Site Layout

2.3.2 Rail System

The rail network, upon which the WP transporter travels, is part of the Subsurface Emplacement Transportation System. The following discussion is included to assist in identifying interfaces between the rail system and the emplacement/retrieval system.

2.3.2.1 Rail and Track

The locomotives and WP transporter use a track gauge of 1.44 m (56.5 in.) ("Waste Package Transport and Transfer Alternatives," Section 4.2.2). An American Institute of Steel Construction standard crane rail of 67 kg/m (135 lb/yd) will be used in the North Ramp, in all the main drifts and turnouts, and for the rail line leading to the WHB ("Waste Package Transport and Transfer Alternatives," Section 5.6). The rail system is designed for the design loads imposed on the rail by the locomotives and transporter. The bounding weight used in the calculations for a loaded transporter is 400 metric tons ("Waste Package Transport and Transfer Alternatives," Section 6.4.3.4) and includes the following:

- The heaviest WP, 85 metric tons
- The pallet, 3 metric tons
- The bed plate with rollers, 10 metric tons
- Transporter shielding and fixed equipment, 153 metric tons
- The transporter flat deck car, 136 metric tons

The trucks and wheels for the locomotives and transporter are designed to negotiate the 20-m (65.6-ft) curve radius that is the design basis of the track system. The curvature of the emplacement drift turnouts imposes this 20-m (65.6-ft) radius limitation ("Waste Package Transport and Transfer Alternatives," Section 4.2.6). The North Ramp and other main drifts will have curvatures with a maximum 305-m (1,000-ft) radius ("Waste Package Transport and Transfer Alternatives," Section 4.2.6). That limitation is not driven by the rail alignment, but by the allowable curvature of the muck conveyor system used during excavation to avoid transfer stations, and by the already established Exploratory Studies Facility (ESF) layout.

The steepest railroad grade for emplacement operations is 2.15 percent, which is found in the existing North Ramp. This is well within the operational limit for the proposed locomotives ("Subsurface Transporter Safety Systems Analysis," Section 6.2). Rail grades in the South Ramp are steeper ("Subsurface Transporter Safety Systems Analysis," Section 6.2) and may be used for retrieval, restoration, or recovery.

2.3.2.2 Electrification

A direct-current electrification system will be used as the primary means of rail electrification. Based on the projected power requirements, a 750-volt DC system is preferred because it minimizes the required number of rectifiers. It is also a common rating used by the rail and mass transit industries ("Repository Rail Electrification Analysis," Section 8.1).

The electrification system will use two different means of providing power to the subsurface drifts. For the main access ramps and turnouts, an overhead trolley wire system will be used. A pantograph, which is a wide contactor supported by a hinged, diamond-shaped structure mounted on the roof of the locomotive, serves as the collection device. In the emplacement drifts, a third-rail system is utilized. The third-rail system, with standard side collector, provides a low profile means of electrifying the emplacement and performance confirmation gantries ("Repository Rail Electrification Analysis," Sections 8.2 and 8.3).

In both electrical systems, the rails act as the ground, completing the circuit ("Repository Rail Electrification Analysis," Section 7.8.4). Both also meet repository requirements for space limitations, maintainability, temperature, and radiation ("Repository Rail Electrification Analysis," Section 8.3).

2.3.3 Emplacement Waste Package Handling Sequence

In the early years of emplacement, a typical route for a loaded transporter is as follows:

- Two locomotives, one leading and one trailing, will move the loaded transporter from the WHB to the North Portal as depicted in Figure 2

- The train will then proceed down the North Ramp to the North Ramp extension, and from there to the preselected emplacement drift turnout. The train will generally follow the shortest route to the emplacement drift; however, orientation of the transporter is important depending on whether the emplacement drift is going to be reached from the east or west mains.

- The open deck of the transporter has to face the drift docking area for transfer of the WP. The transporter and locomotives, once they enter the subsurface area in the early emplacement years, cannot rotate or change the orientation of the transporter. Therefore, the transporter must be oriented in the proper direction at the surface facilities using railroad turnouts.

- The return trip to the surface will follow the same route in the reverse sequence. The open deck of the transporter must face the WHB to accept another WP. Therefore, the transporter must be properly oriented before docking at the WHB.

Figure 2. Locomotives and Waste Package Transporter Approaching the North Portal

A typical route from the WHB to an emplacement drift will change as construction of the repository and emplacement activities continue. The open deck of the transporter must still face the emplacement drift docking area to transfer a WP, and it must still face the WHB to accept another WP. This can be achieved by making a circular route all the way around the repository perimeter mains, or by switching the direction of the train at the surface turnouts or at locations where the North Ramp and the North Ramp extension meet the east main.

The WP handling sequence of operations is detailed below and will not change throughout the waste emplacement period ("Subsurface Transporter Safety Systems Analysis," Section 6.1; and "Waste Package Transport and Transfer Alternatives," Section 6.1):

1. The WP is placed on a pallet on the deck of the transporter waiting at the receiving dock in the WHB.

2. A semi-rigid chain mechanism pulls the pallet and WP into the shielded enclosure of the transporter.

3. The shielded enclosure doors are closed to protect the operators, and a primary locomotive pulls the loaded transporter away from the WHB docking area.

4. During a stop at a track turnout outside the WHB, a secondary locomotive joins the train by coupling itself to the transporter. Both locomotives are manually controlled by operators.

5. Both locomotives, one in front and one behind, move the loaded transporter into the subsurface facilities. The locomotives and the transporter will operate within the space clearances in the North Ramp, North Ramp extension, and main drifts. The main drifts will be excavated to the same diameter as the ramps, 7.62 m (25.0 ft) ("Site Recommendation Subsurface Layout," Section 6.2.1.1). Figure 3 illustrates a main drift cross-section depicting the invert, rails, locomotive, and transporter.

6. The train stops near the predetermined emplacement drift turnout.

7. The locomotive controls are turned over to remote control operators in a control center at the surface. The locomotive operators then move to a designated location to protect themselves from radiation while the emplacement drift doors are open.

8. The locomotive in front of the transporter is uncoupled from the transporter by remote control operators and moved to a standby location.

9. The locomotive behind the transporter moves the transporter into the turnout and stops before reaching the emplacement drift docking area.

Figure 3. Typical Cross-Section of a Main Drift Showing Waste Package Transportation Equipment

10. The shielded transporter enclosure doors and the emplacement drift isolation doors are fully opened from the surface control center.

11. The locomotive docks the transporter, pushing the open deck section of the transporter completely inside the docking area.

12. The semi-rigid chain mechanism pushes the pallet and WP from inside the shielded transporter enclosure to the open deck area of the transporter, depicted in Figure 4 and Figure 5.

13. The WP emplacement gantry, which operates on the emplacement drift rails and is also remotely-operated, moves over the WP and pallet, straddling the transporter's open deck. The gantry is placed in the emplacement drift prior to the start of emplacement operations in a particular drift.

14. The gantry then lifts the WP by its pallet and moves to the WP emplacement location inside the emplacement drift.

15. The locomotive moves the transporter away from the emplacement drift docking area and stops. The shielded transporter enclosure doors and the drift isolation doors are closed.

16. The locomotive moves the transporter from the turnout to the main drift and stops to allow the second locomotive to couple to the train.

17. The operators re-board the locomotives, the controls are turned back to manual operation, and the train proceeds to the surface.

18. Before docking at the WHB, the train stops, the locomotive in front of the transporter is uncoupled and moved away to a standby location. The other locomotive then moves the transporter to the building dock for pickup and subsequent emplacement of another WP.

2.3.4 Normal Retrieval Waste Package Handling Sequence

The emplacement drifts will be monitored periodically, with an expected inspection frequency of 10 years. A remotely operated inspection gantry would be used during those inspections. Such performance confirmation monitoring will provide data on drift conditions that would be used to plan retrieval activities ("Performance Confirmation Emplacement Drift Monitoring System Description Document," Section 1.2.1.4).

If it were decided that spent nuclear fuel would be retrieved from the repository, this data gathered from emplacement drift monitoring and additional case-specific monitoring would be reviewed. If drift conditions were normal, retrieval operations would be executed using the same WP emplacement equipment as that used for emplacement, but in reverse sequence. Use of the same equipment provides a built-in capability for retrieval that can be readily implemented. To

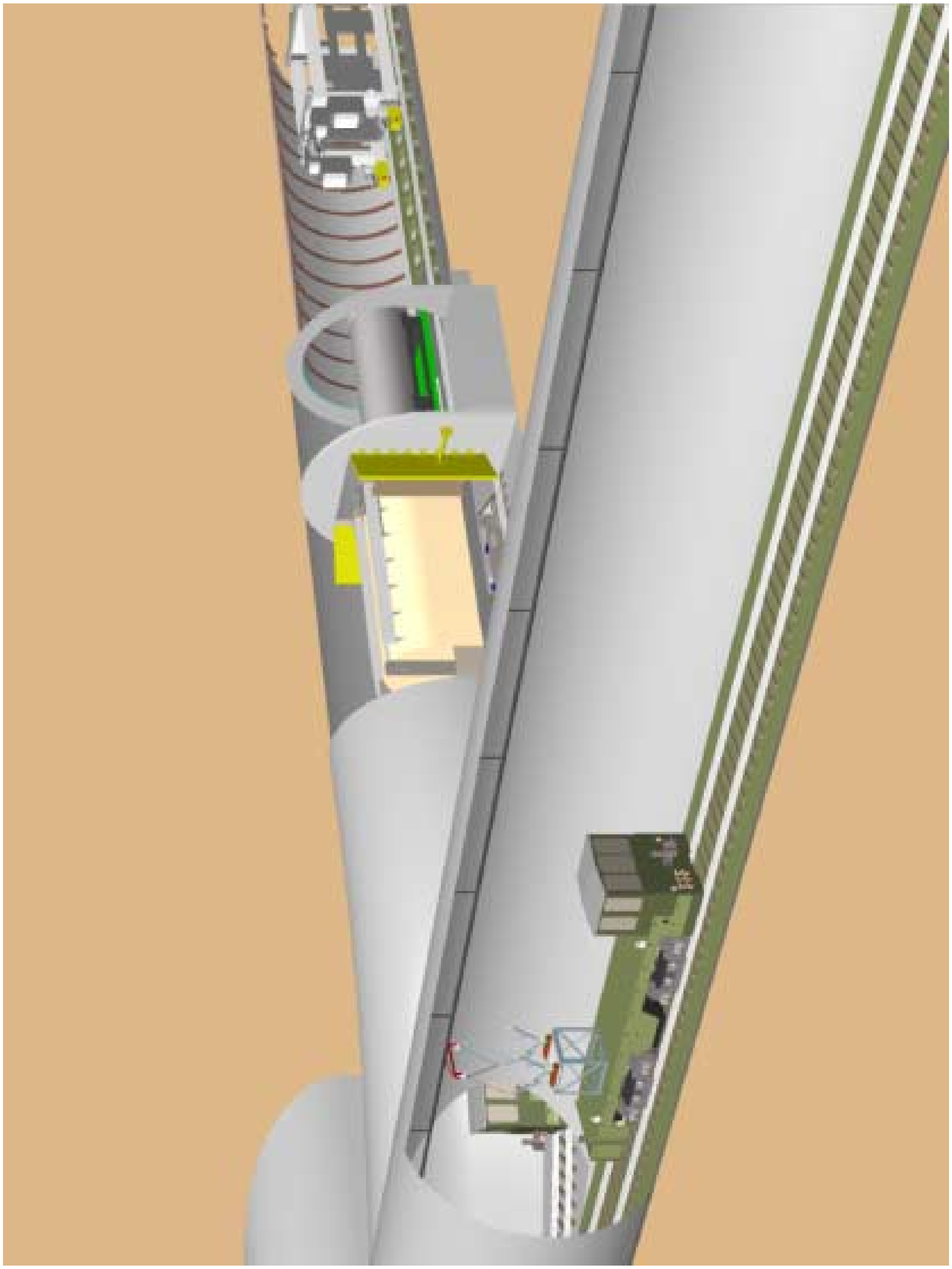

Figure 4. One Locomotive on Standby while the Other Locomotive Moves the Transporter into the Turnout

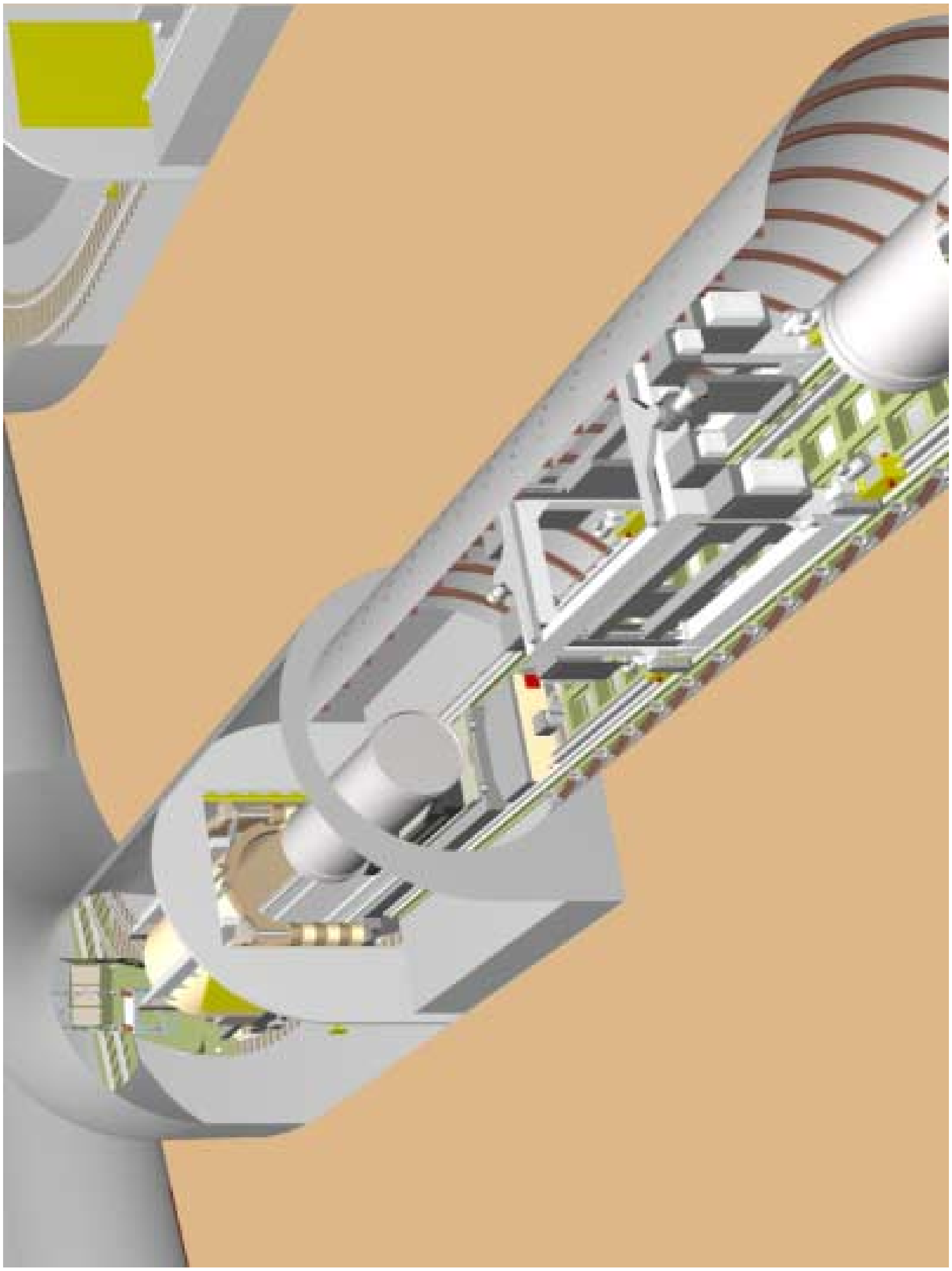

Figure 5. Docked Transporter with Pallet and Waste Package on Transporter's Open Deck and Emplacement Gantry Approaching the Docking Area for Pickup

maintain air temperatures below 50°C (122°F) during retrieval, the ventilation flow rates may have to be adjusted several weeks before the incursion into the drift ("Retrievability Strategy Report," Section 7.7.1.2).

The normal retrieval sequence of operations is illustrated in Figure 6 and described below ("Waste Package Retrieval Equipment," Section 7.1.1.4 and "Retrieval Equipment and Strategy for WP on Pallet," Section 6.1.2).

1. The locomotive and loaded gantry carrier travel to the emplacement drift.

2. The emplacement drift isolation doors are opened, and the loaded gantry carrier engages the emplacement drift dock.

3. The gantry moves off the gantry carrier, and the carrier is removed from the drift.

4. The drift isolation doors are closed, and the gantry moves to the location of the nearest WP.

5. The gantry picks up the pallet and WP and moves back to the emplacement drift dock.

6. The transport locomotive and empty WP transporter move to the main drift adjacent to the emplacement drift.

7. A secondary locomotive decouples ahead of the drift entrance. The primary locomotive and WP transporter move from the main drift into the drift turnout.

8. The drift isolation doors open, the WP transporter docks, and the WP transporter doors open.

9. The loaded gantry moves over the open deck of the transporter, deposits the pallet and WP on the open deck, and moves back into the drift.

10. The pallet and WP are pulled into the shielded compartment of the transporter.

11. The transporter doors close and the primary locomotive moves the WP transporter away from the edge of the emplacement drift.

12. The primary locomotive and WP transporter move from the turnout into the main drift.

13. The secondary locomotive couples to the rear of the WP transporter, and the train moves to surface.

NOTE: Steps 4 through 13 are repeated for each WP to be retrieved from the drift.

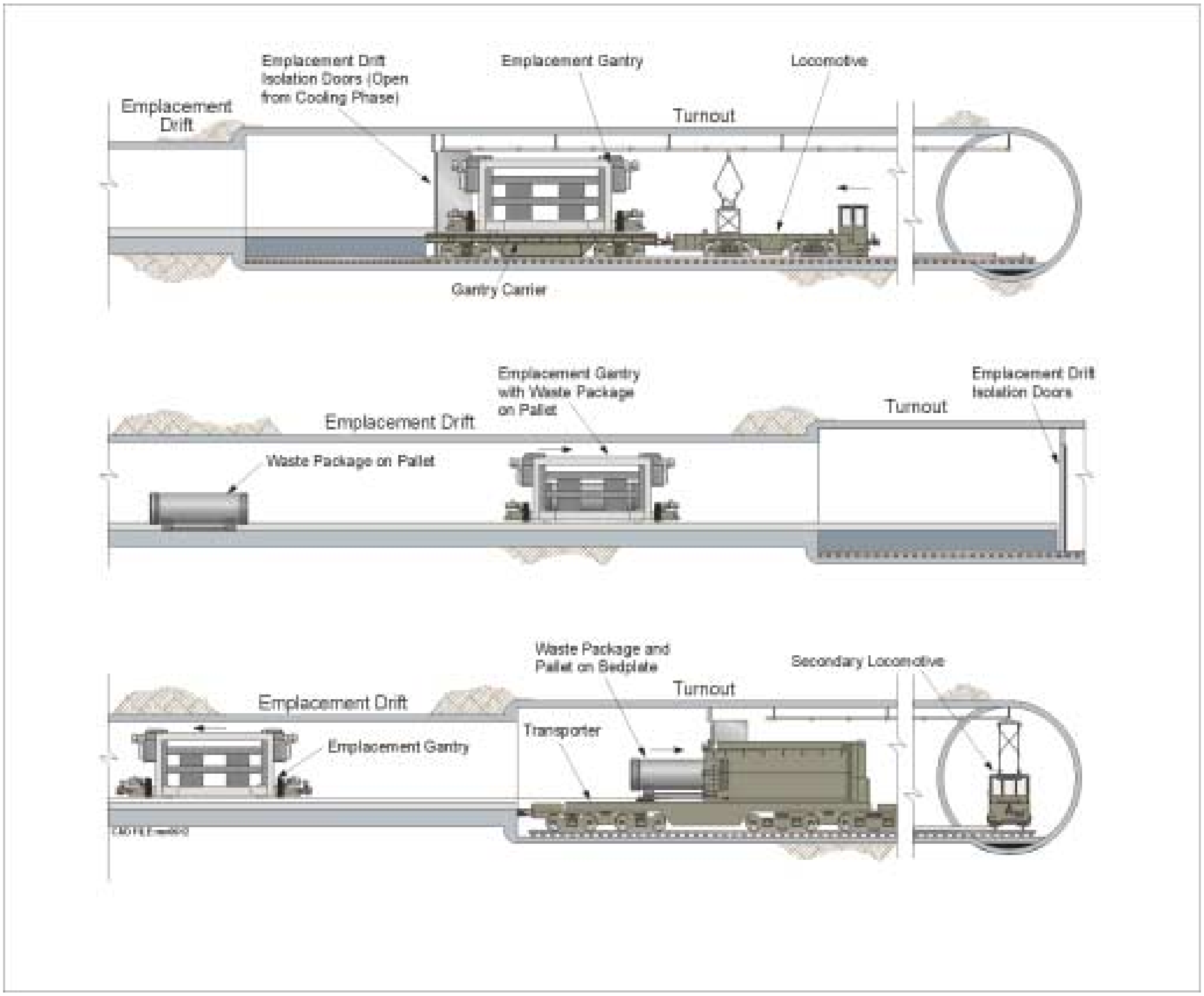

Figure 6. Equipment and Sequence of Operations for Normal Retrieval

14. The locomotive moves the gantry carrier from the main drift to the emplacement drift turnout.

15. The drift doors are opened and the gantry carrier engages the emplacement drift dock.

16. The gantry is moved onto the gantry carrier, the locomotive pulls the loaded carrier away from the emplacement drift dock, and the drift isolation doors close.

17. The locomotive and the loaded gantry carrier move from the turnout to the main drift and return to a standby location.

Retrieved WPs that are in good condition will be taken to the surface and staged in a dedicated area within the surface facilities complex. If a damaged WP or a drift condition preventing normal retrieval or recovery is encountered, the sequence is interrupted, and a contingency plan initiated to mitigate the problem (see Section 2.3.5 below). Damaged WPs, or WPs suspected of being damaged, will be taken to the WHB for detailed inspection, repairs, or repackaging.

Individual WP recovery for inspection, testing, and emplacement drift maintenance is not considered retrieval; however, WP recovery for these purposes, if needed, would involve the same equipment and operational steps. If a specific WP to be recovered is not readily available from the drift entrance, all WPs in front of it would have to be temporarily relocated to another emplacement drift following a sequence of events similar to that described above.

The locomotives, gantry, gantry carrier, and WP transporter used for normal retrieval and recovery are the same as those used for emplacement. They are described in Section 2.4 below.

2.3.5 Abnormal Retrieval Procedures

When the equipment and operating sequence described above cannot be used, retrieval or recovery conditions are considered abnormal. A series of design basis events that could affect normal conditions were analyzed ("Retrieval Equipment and Strategy" and "Retrieval Equipment and Strategy for WP on Pallet") to determine the operational procedure and type of equipment that could be used for restoration and recovery of WPs. The two design basis events analyzed and of particular relevance to abnormal retrieval conditions in the emplacement drifts were:

- Rockfall or ground support collapse onto a WP (from causes other than seismic events)
- Rockfall or ground support collapse onto a WP caused by a seismic event

Other design basis events analyzed with respect to abnormal recovery and restoration operations pertain to the mechanical failure of the gantry and the derailment of the gantry at normal speed.

Under abnormal conditions, several additional operations would be added to the retrieval or recovery sequence ("Retrieval Equipment and Strategy for WP on Pallet," Section 6.2). These additional steps would most likely include the following:

1. Assessing nuclear and non-nuclear safety.
2. Establishment of radiation controls and other administrative controls for the recovery of a damaged or breached WP.
3. Confining contamination, if present.
4. Monitoring and detailed characterization of damage.
5. Development of a case-specific contingency plan.
6. Cleanup and removal of debris.
7. Stabilization of the drift (including ground support repairs or replacement).
8. Repairing the tracks and other damaged structures and utilities.
9. Repositioning or recovery of the pallet and WP, if necessary.

Two pieces of equipment specifically designed for restoration and abnormal recovery operations ("Retrieval Equipment and Strategy for WP on Pallet," Section 6.2.4) are the emplacement drift gantry carrier and the multi-purpose hauler depicted in Figure 7. These two pieces of equipment operate as described in Section 2.4.5 to accomplish the above tasks.

2.3.6 Instrumentation and Controls

All emplacement/retrieval operations are remotely controlled from a central control room except for the rail transfer of the WP to or from the subsurface facility. This is accomplished using a pair of locomotives operated manually but with remote monitoring and supervision ("Subsurface Transporter Safety Systems Analysis," Section 6.1.4).

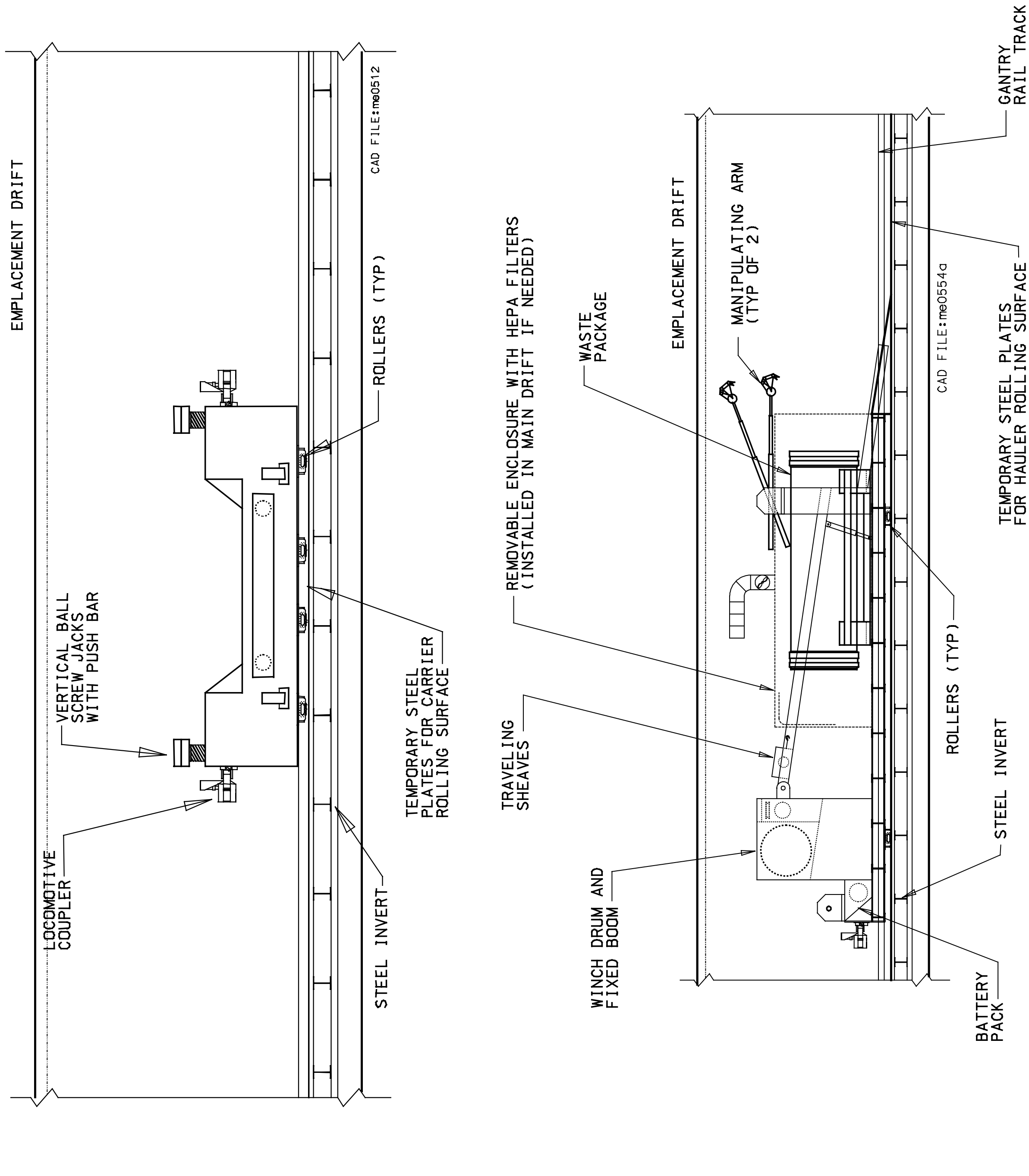

Figure 7. Emplacement Drift Gantry Carrier and Multi-purpose Hauler

Control and monitoring signals to and from the system are transmitted using radio frequency, leaky feeder, or microwave devices to a communications node and then by fiber optic cable to a central control room. The network is illustrated in Figure 8 (“Instrumentation and Controls for Waste Emplacement,” Figure 10). Interfaces with the Subsurface Emplacement Transportation System, the Subsurface Ventilation System, and the Performance Confirmation Emplacement Drift Monitoring System are also shown on the figure for reference.

The emplacement/retrieval control and monitoring system will employ programmable logic controllers (PLCs) or microprocessor units in a redundant configuration to ensure reliable operations. The units may be designed to operate in parallel and employ a voting strategy where both have to agree before implementing a command or confirming a condition. They could also be configured as an active primary system with a standby backup (“Instrumentation and Controls for Waste Emplacement,” Section 6.5.2).

Order-of-magnitude estimates of control and monitoring system input/output (I/O) signals for the various components in the emplacement/retrieval system are summarized in Appendix E.

2.3.7 Waste Package Transport System Safety Analyses

A safety analysis (“Subsurface Transporter Safety Systems Analysis”) was performed for the WP transport system to determine its compliance with preclosure safety requirements. The analysis addressed scenarios for a runaway train and derailment, tip-over determinations, effectiveness of impact limiters, and mitigation of uncontrolled descents. During the development of the analysis, several safety features were identified and evaluated, resulting in the additional system components described in Appendix F.

2.4 COMPONENT DESCRIPTION

Principal components of the emplacement/retrieval system include the transporter, the locomotives, an emplacement gantry, an emplacement drift gantry carrier, and a multi-purpose hauler. The WP pallet is a component of the Emplacement Drift System (“Emplacement Drift System Description Document,” Appendix B) but is included in the following discussion to illustrate interface with the transporter and emplacement gantry.

2.4.1 Pallet

Figure 9 provides an isometric view of an emplacement pallet. There are two sizes of pallets: one designed for the majority of the WPs, and a second, shorter version used for the 5-defense high-level waste/U.S. Department of Energy spent nuclear fuel WP (“Design Analysis for the Ex-Container Components,” Section 6.2).

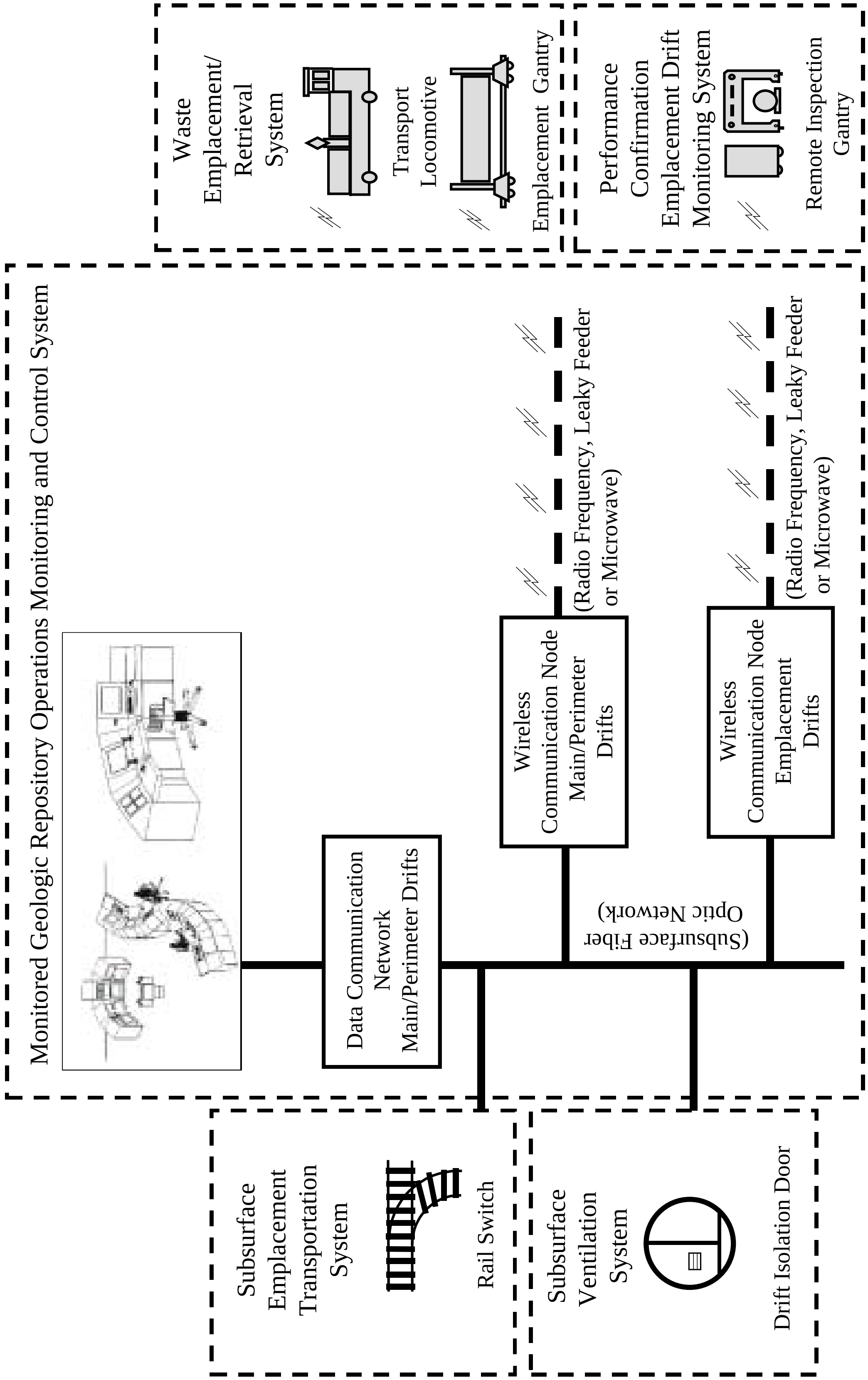

Figure 8. Operations Monitoring and Control System Interfaces

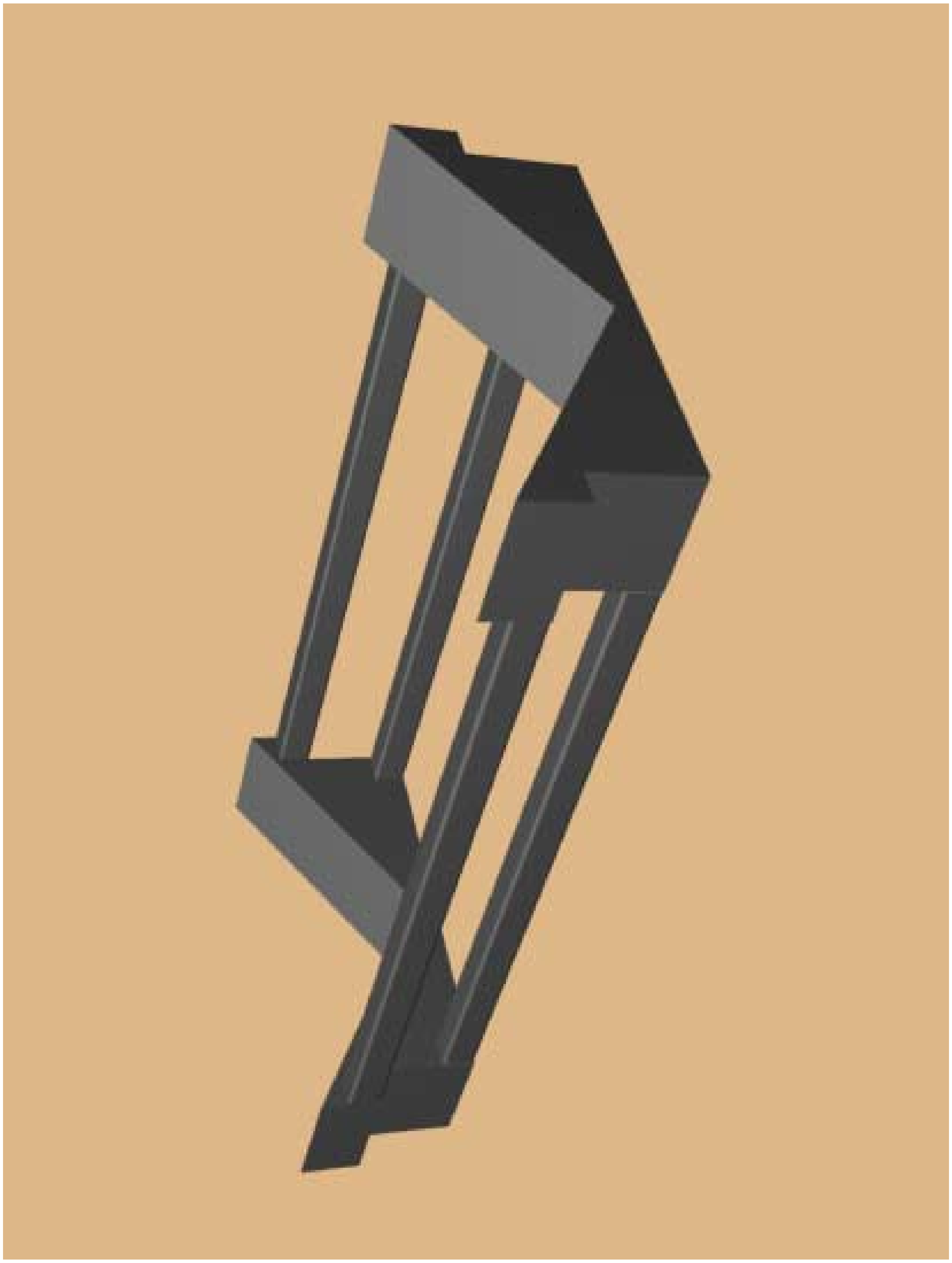

Figure 9. Emplacement Pallet Isometric View

As illustrated in Figure 10, the ends of the WP extend past the ends of the emplacement pallet which allows the WPs to be placed end to end (line-loading), within 10 cm (4 in.) of each other ("Bottom/Side Lift Gantry Conceptual Design," Section 6.3 and "Emplacement Drift System Description Document," Section 1.2.1.6).

The emplacement pallet will be used to support the WP during transport from the WHB to the emplacement drift, and will also support the WP in the emplacement drift permanently. The pallet will be lifted at the support points depicted in Figure 10. The pallet meets the design criterion for structural strength ("Emplacement Drift System Description Document," Section 1.2.1.22) during lifting, under the weight of the heaviest WP, as documented in "Design Analysis for the Ex-Container Components," Section 6.4.

Because WPs must be retrievable or recoverable for a period of up to 300 years ("Retrieval Equipment and Strategy for WP on Pallet," Section 4.2.10), the pallet must remain in a condition that can be lifted even at the end of this period. Necessary calculations have been done to support this design criterion ("Design Analysis for the Ex-Container Components," Section 6.2.2.1). Seismic activity could also affect the ability of the pallet to maintain the normal WP position. The required seismic calculations will be performed later in support of License Application ("Design Analysis for the Ex-Container Components," Section 6.2.2.1).

2.4.2 Transporter

The WP transporter consists of a flat railroad car 22 m (72.4 ft) in length, with a WP shielding structure at one end and an open deck at the other end. Ancillary equipment installed on the transporter includes mechanisms for opening and closing the shielded doors; a bed plate supported on rollers; and a semi-rigid chain mechanism and tracks for rolling the bed plate in and out of the shielded enclosure ("Waste Package Transport and Transfer Alternatives," Sections 6.4 and 7.3). Figure 11 depicts the transporter and its components.

This WP transporter design with an integrated transfer deck eliminates the complexities of aligning several separate components at the WP transfer locations ("Waste Package Transport and Transfer Alternatives," Table 12). The integrated transporter design with the shielded enclosure located toward one end of the flat deck car allows the open deck area to extend adequately beyond the shielding structure. This permits the WP and pallet to be moved together out of the enclosure and positioned for access by the emplacement gantry. The WP transporter is docked between the rails of the emplacement gantry in the emplacement drift, enabling the emplacement gantry to straddle the transfer deck to pick up the WP and pallet.

Figure 10. Emplacement Pallet Loaded with Waste Package

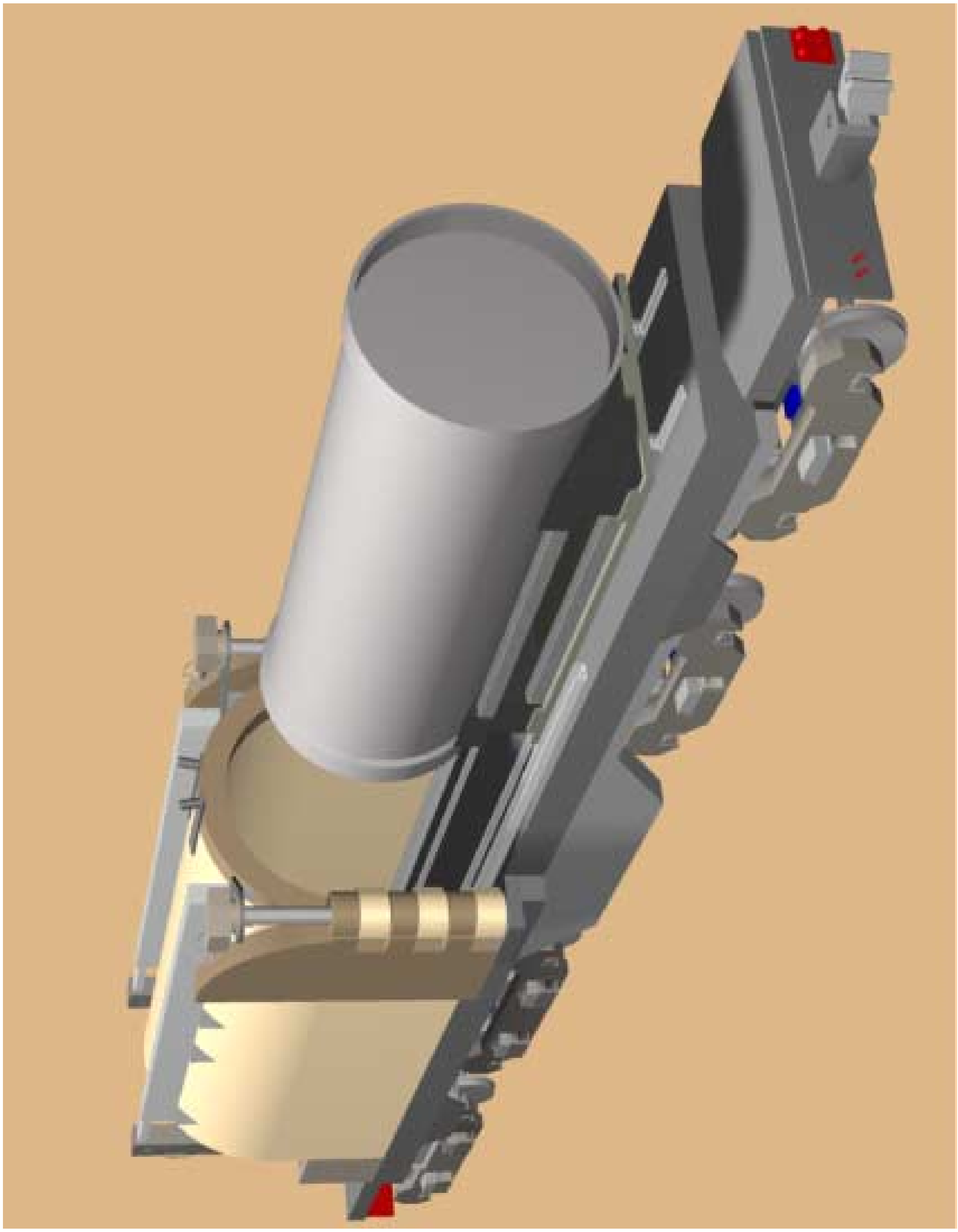

Figure 11. Waste Package Transporter and its Components

A bed plate sized to contain and restrain the pallet has four low-profile, heavy-duty rollers affixed to its underside to aid movement of the WP out of the shielded enclosure. After the emplacement gantry engages the pallet and raises the loaded pallet high enough to clear the bed plate, the bed plate is retracted back into the shielded enclosure. This transporter design eliminates the need for precise alignment of tracks between the transporter and the emplacement drift. It also diminishes the possibilities for WP mishandling and dropping incidents ("Waste Package Transport and Transfer Alternatives," Section 6.4.1).

The gantry lifting screw limits the height the WP can be lifted to approximately 810 mm (2.7 feet) above the deck of the transporter ("Bottom/Side Lift Gantry Conceptual Design," Section 7.2.4). This maximum height limit is much less than the allowed limit (Criterion 1.2.2.1.3). To eliminate the risk of dropping a WP in the docking area, the transporter remains in the area until the loaded gantry moves back into the emplacement drift.

Design calculations for the transporter ("Waste Package Transport and Transfer Alternatives," Sections 6.4.6.1, 6.4.6.2 and 6.4.6.3) were done for various static and dynamic loading conditions, which resulted in the selection of industry standard 320 BHN (Brinnel hardness number) wheels and rails. The wheels have a diameter of 762 mm (30 in.) and are installed on dual 3-axle trucks in the rear of the transporter and dual 2-axle trucks in the front.

The bed plate consists of a thick steel plate that distributes the WP and pallet load through rollers (attached to the bottom of the bed plate) to the transporter. The design uses reliable, low-profile unitary rollers. The roller assembly runs on an inverted channel installed on the deck of the transporter. The channel guides the bed plate rollers to a central position for pickup by the emplacement gantry. The bed plate is attached to the ends of two gear-driven, semi-rigid chains that run in floor-mounted guides on each side of and parallel to the bed plate as it rests on the transporter. The chain guides extend from inside the shielded enclosure along the transfer deck. The semi-rigid chain is utilized to push the bed plate out of and then return it to the transporter shielded enclosure after the WP is removed by the gantry. The bed plate incorporates restraints and spacers to immobilize the WP, pallet, and bed plate inside the transporter while in transit to the emplacement drift ("Waste Package Transport and Transfer Alternatives," Sections 6.4.1 and 6.4.2).

The design goal for the shielded enclosure (which has not yet been evaluated for the maximum WP surface dose rate) is a dose rate of no more than 100 mrem/hr on the transporter surface. The shielded enclosure wall is A-516 steel with a thickness of 171.5 mm (6.75 in.) in the radial direction and a wall thickness of 196.9 mm (7.75 in.) in the axial direction. An A-516 steel thickness of 152.4 mm (6 in.) is used for the deck floor below the shielded enclosure. In addition to the A-516 steel, the shielded enclosure has a borated polyethylene layer for neutron shielding ("Waste Package Transport and Transfer Alternatives," Section 6.7).

2.4.3 Locomotives

The two locomotives for transporting WPs will be 50-ton, 4-axle units. As discussed in Section 2.3.2.2, the locomotives use electrical power (750-volt DC, nominal) supplied through an overhead catenary wire and a pantograph. The overhead catenary wires will be installed in all drifts and turnouts where the locomotives will operate. Each locomotive has dual direct-current electric motors rated at 170 hp each ("Mobile Waste Handling Support Equipment," Section 7.3).

Other functions performed by the waste transport locomotives include:

- Transporting WPs to the surface in support of retrieval operations if necessary

- Transporting WPs between drifts, as needed, to support repository operations and maintenance activities

- Transporting the emplacement gantry carrier from the surface to the emplacement drift turnouts and from drift to drift.

For redundancy and added safety, two locomotives will be used anytime the transporter is mobilized (except during docking operations at the WHB and at the emplacement drift turnouts, where only one locomotive is used). One locomotive will be in front of and the other behind the transporter. Safety analyses of the locomotives and WP transport operations are discussed in Appendix F.

The maximum operating speed for the locomotives and transporter has been defined as 8 km/hr (5 mph) (Criterion 1.2.2.1.2). Standard underground industry practice defines 16 km/hr (10 mph) as the maximum standard operating speed for locomotive travel within a mine environment ("Subsurface Transporter Safety Systems Analysis," Section 6.6). Therefore, the selected train operating speed for the repository is well within safety limits established by the industry.

2.4.4 Emplacement Gantry

The gantry developed to handle the WP and pallet is a bottom/side lift type ("Bottom/Side Lift Gantry Conceptual Design"). The gantry, illustrated in Figure 12, rides on 67 kg/m (135 lb/yd) crane rails ("Waste Package Transport and Transfer Alternatives," Section 6.4.6.2) with a rail centerline to rail centerline distance of 2.95 m (8.20 ft) ("Bottom/Side Lift Gantry Conceptual Design," Section 6.3). The gantry has been designed so it will not drop a WP or become inoperable as a result of a seismic Category 1 design basis event ("Bottom/Side Lift Gantry Conceptual Design," Section 6.3).

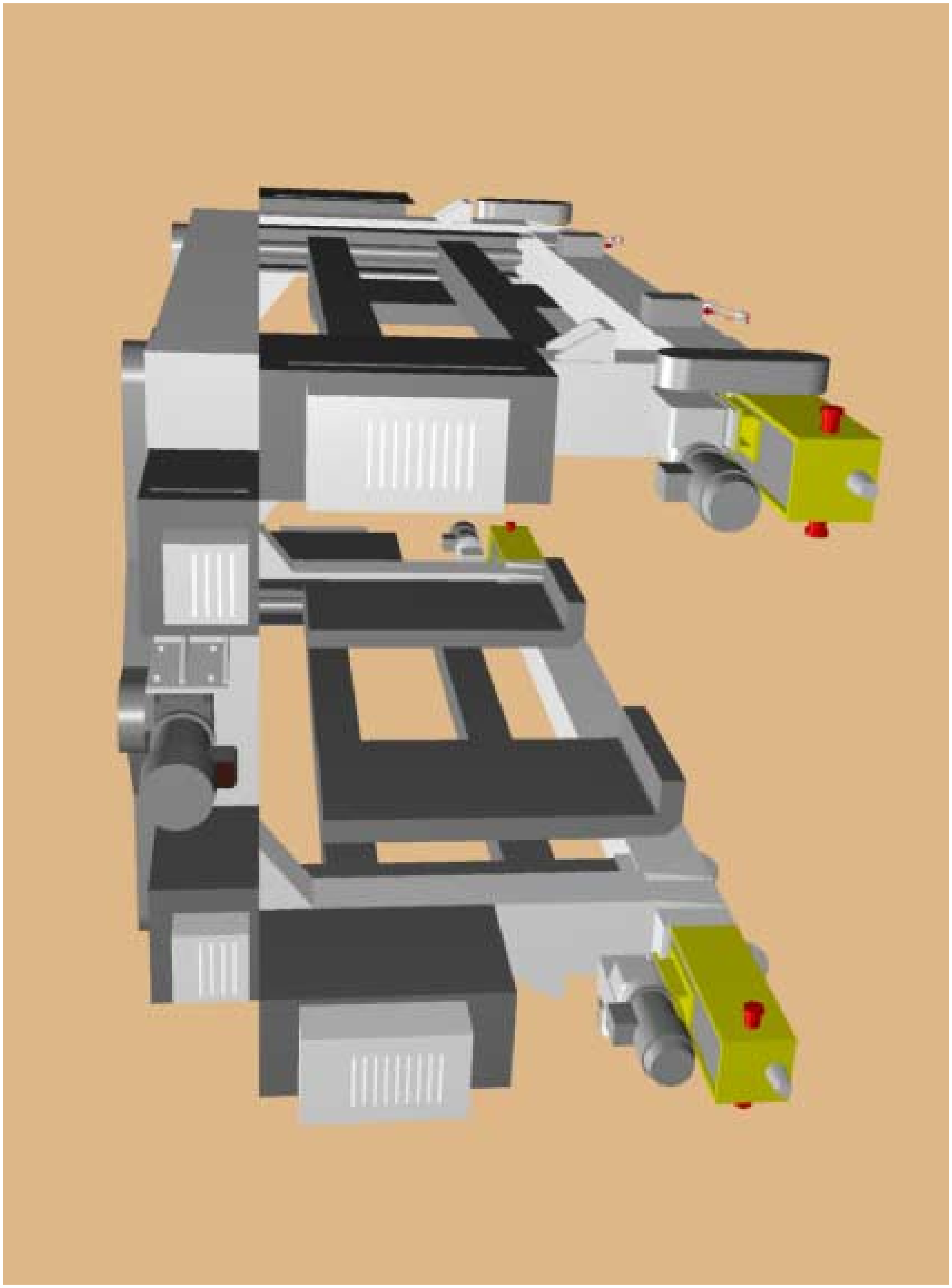

Figure 12. Bottom/Side Lift Emplacement Gantry – Perspective View

The gantry is designed to operate in the elevated-temperature, high-radiation environment inside the emplacement drifts. The gantry will only move forward and backward on the rails and the lifting hooks will only move up and down vertically. This simplified set of operating requirements reduces the complexity of the gantry's mechanical, electrical, and control systems, which makes the gantry inherently reliable. The incorporation of dual-redundant programmable control computers, instruments, and communications equipment enhances control system reliability. Fault-tolerant operation is ensured by physically separating the redundant components, providing backup electrical power and data communication systems, and employing diverse technologies that will not be susceptible to similar failures from a single cause. Shielded and insulated cabinets protect the heat- and radiation-sensitive instrumentation, and solid-state air conditioning units regulate the temperature. Built-in fire detection will automatically activate fire suppression systems should an onboard fire be detected ("Bottom/Side Lift Gantry Conceptual Design," Section 6.6).

The primary source of electric power for the gantry is an electrified third rail (conductor bar) system. The vehicle will have redundant power pickup mechanisms to ensure a reliable and continuous connection to the source of power. The gantry will have an emergency backup power system (onboard rechargeable storage batteries) with enough power to lower and release a WP and return to the drift entrance. The locomotion system will have four independent, direct-current drive motors, with one motor at each of the wheel assemblies. The maximum operating speed that the gantry can travel when carrying an 88-metric ton load is limited to 2.7 km/hr (1.7 mph or 150 ft/min.). The gantry will have independent fail-safe braking systems (a primary system and an emergency system). In the event of a power or communication loss, or of a vehicle control system malfunction, the braking systems will engage and bring the gantry to a stop ("Bottom/Side Lift Gantry Conceptual Design," Section 6.6).

A video system will be installed on the gantry to provide operators at the remote control center with real-time visual information about the operating environment and vehicle performance. This system will consist of several onboard, high-resolution closed-circuit television cameras and a series of high-intensity lights. Thermal and radiological sensing instrumentation will also be installed on the gantry to provide the remote control center with real-time readings in the emplacement drift ("Bottom/Side Lift Gantry Conceptual Design," Section 6.6).

The rails in the emplacement drifts, upon which the gantry travels, are continuous from the east to the west end. However, a ventilation access called a "raise," which connects the drift to the exhaust main below, interrupts gantry travel. The raise is located approximately at the midpoint of each drift. Because the gantry cannot lift a pallet and WP over a previously emplaced WP, emplacement in each half of the drift starts at the raise, where the rail ends. Emplacement progresses from the raise toward the drift entrance until that half of the drift is full.

Although the emplacement of WPs is limited by the location of the raise, access for abnormal retrieval and recovery can proceed from both sides of the drift using the multi-purpose hauler and multi-purpose vehicle (see Section 2.4.5).

The gantry will operate within the clearances inside the 5.5-m (18.0-ft) diameter emplacement drifts ("Bottom/Side Lift Gantry Conceptual Design," Section 6.3) as illustrated in Figure 13. Before picking up a WP, the vertical positions of the lifting fingers or hooks will be adjusted so the hooks can slip underneath the projecting parts of the pallet structure. The gantry then moves over the units and raises its hooks to engage the pallet structure such that the pallet and its accompanying WP are lifted vertically off the transporter (or off the drift invert during retrieval or recovery).

During normal operations, the gantry will lift a WP and pallet unit approximately 200 mm (8 in.) off the floor of the WP transporter. The gantry keeps the WP and pallet at that elevation when moving. After raising the loaded pallet, the gantry moves the WP to its emplacement location in the drift where it is lowered until the pallet rests directly on the drift floor (invert). The gantry then moves slowly away from the emplaced WP until the hooks are clear. Then, returning to a normal travel speed, the gantry proceeds to the drift entrance to await the arrival of another loaded transporter ("Bottom/Side Lift Gantry Conceptual Design," Section 6.1).

The bottom/side lift gantry is designed to handle a wide range of WP sizes without having to adjust the horizontal spacing of the hooks. This reduces the complexity of mechanical components, thereby increasing their reliability. In addition, the lifting arms never contact the WP, thus eliminating the possibility of WP damage by contact. This gantry concept also allows WPs to be emplaced within 10 cm (4 in.) of each other, end to end ("Bottom/Side Lift Gantry Conceptual Design," Section 7. 1).

The emplacement gantry will not be left inside an emplacement drift for extended idle periods because of the potential detrimental effects of heat and radiation on the gantry sensors and instruments. An emplacement gantry carrier, which is a flatbed railroad car with on-deck rail tracks that mate with the drift tracks is utilized to move the gantry from drift to drift, or to a staging area ("Mobile Waste Handling Support Equipment," Section 7.2.1).

2.4.5 Multi-purpose Hauler and Emplacement Drift Gantry Carrier

Alternate WP retrieval equipment has been identified for abnormal conditions when normal retrieval and recovery procedures may be difficult or impossible. Additional support equipment (i.e., equipment to remove obstacles, prepare surfaces, or install temporary ground supports) that can be used in retrieval operations under abnormal conditions has also been identified ("Retrieval Equipment and Strategy for WP on Pallet").

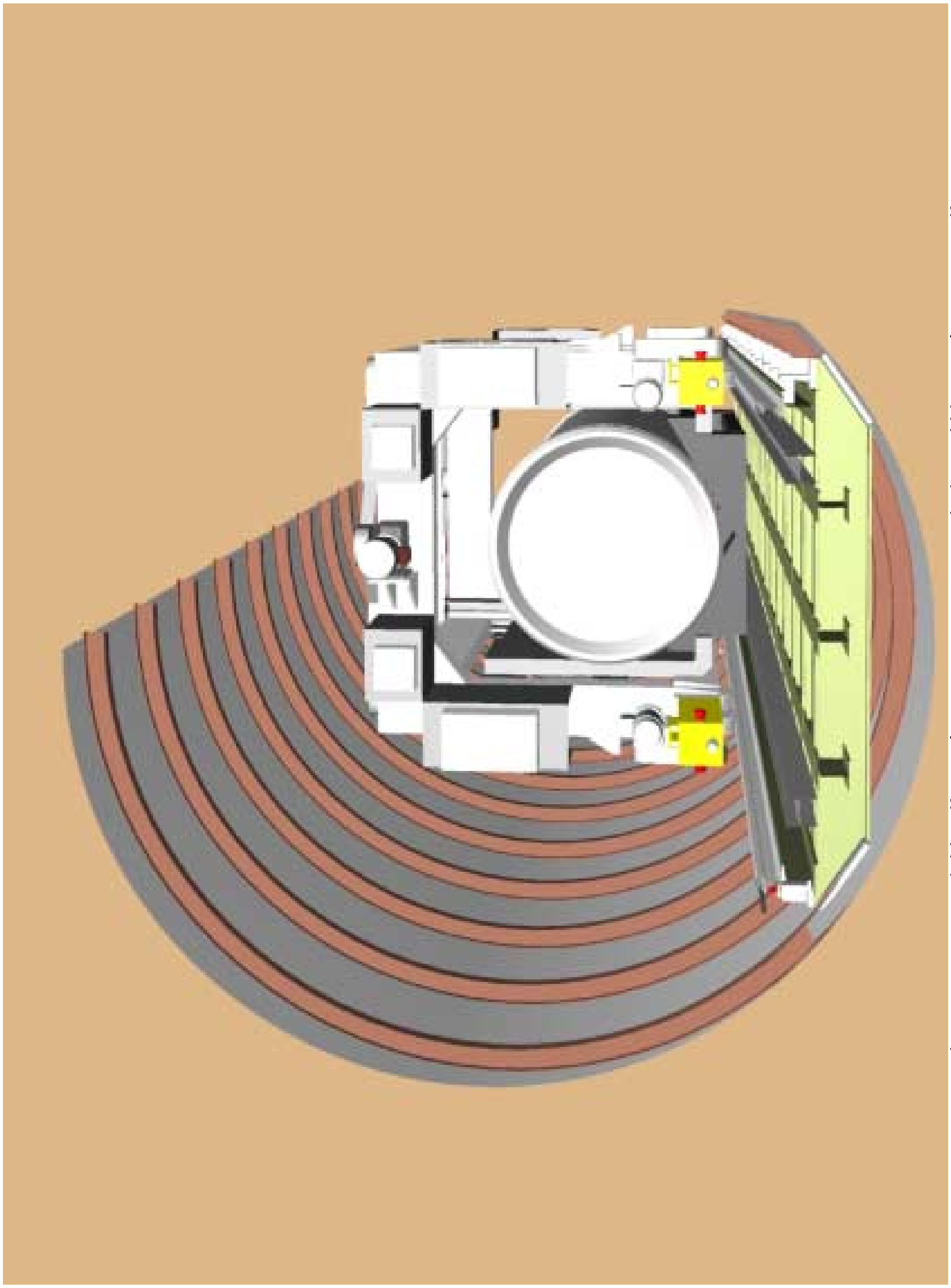

Figure 13. Bottom/Side Lift Emplacement Gantry – End View within Emplacement Drift

The emplacement drift gantry carrier and multi-purpose hauler ("Retrieval Equipment and Strategy for WP on Pallet," Section 6.2.4) are the principal pieces of equipment used in abnormal recovery and restoration activities. This equipment would be remotely controlled and operates on rollers. Steel plates will be installed over the drift invert to deploy these devices.

A multi-purpose vehicle, as shown in Figure 14, will be operated from the multi-purpose hauler to clear debris, emplace steel plates, and cut and remove damaged structures to facilitate deployment. It will then be used to pull and load the pallet and WP onto the deck of the hauler and retrieval operations can proceed ("Retrieval Equipment and Strategy for WP on Pallet," Section 6.2.5).

If a derailed or damaged gantry has to be removed from the drift, an emplacement drift gantry carrier will be deployed to load and carry the gantry out of the emplacement drift. This concept is illustrated in Figure 15 ("Retrieval Equipment and Strategy for WP on Pallet," Section 6.2.4).

Various scenarios of abnormal retrieval have been analyzed, and conceptual use of such equipment has been demonstrated ("Retrieval Equipment and Strategy for WP on Pallet," Sections 6.2 and 6.3). Proof-of-principle demonstrations of WP retrieval will be documented before License Application through supplier performance data. Actual testing will be conducted following the License Application as an additional step in the series of requirements for successful construction and operation of the repository ("Monitored Geologic Repository Project Description Document," CPA 022).

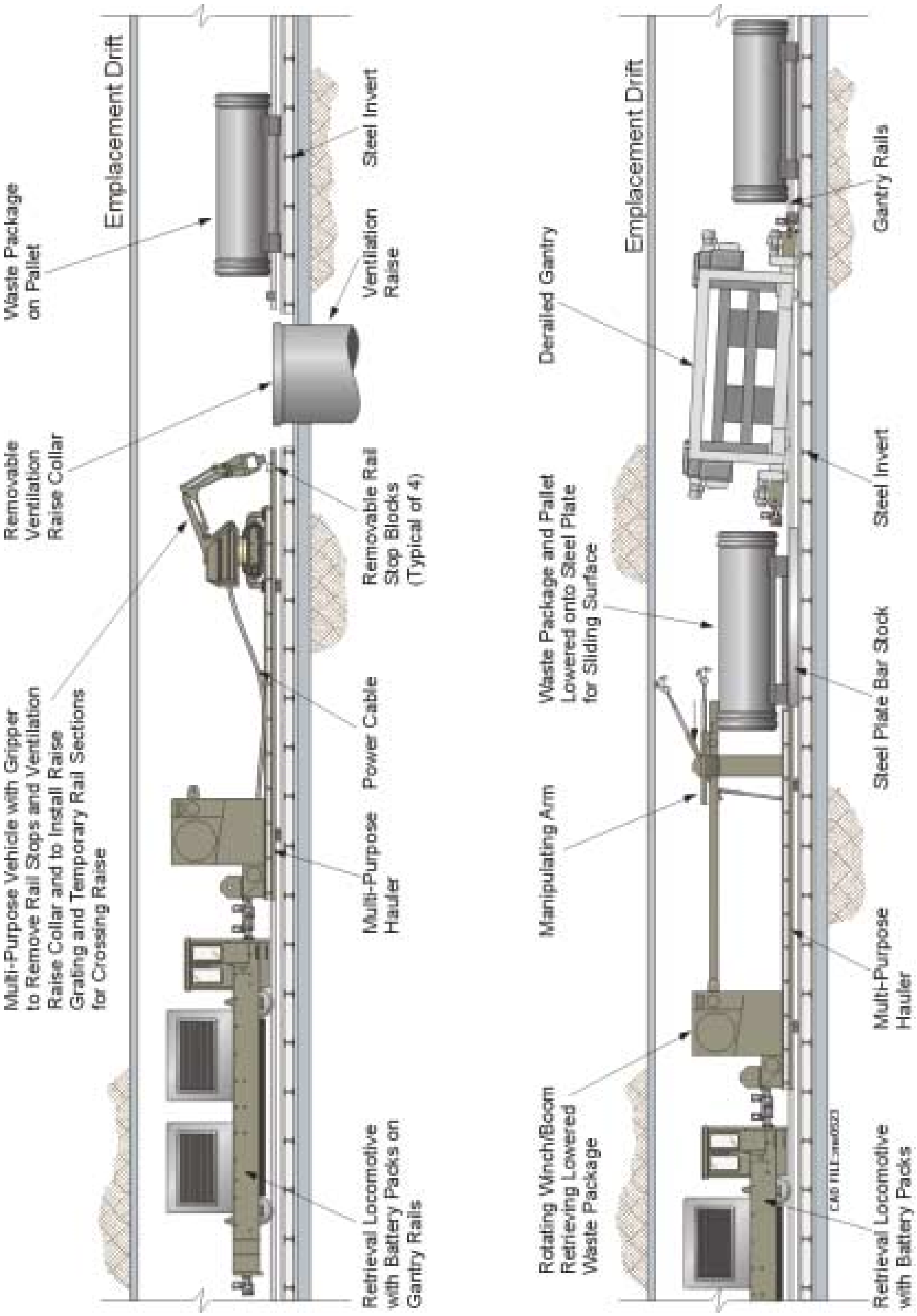

Figure 14. Multi-purpose Hauler Used with Multi-purpose Vehicle for Pallet and Waste Package Retrieval

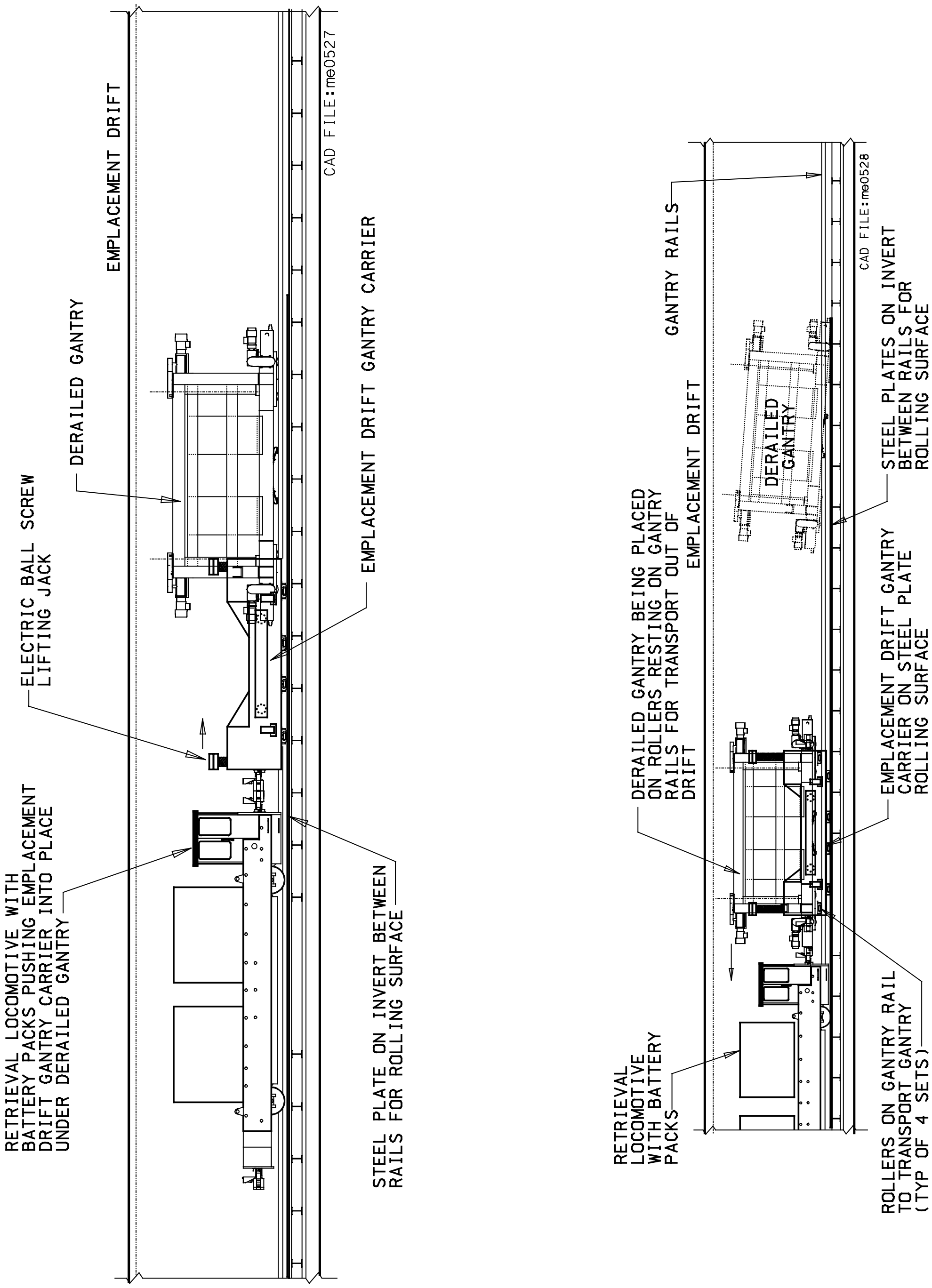

Figure 15. Gantry Recovery with Emplacement Drift Gantry Carrier

2.5 CRITERIA COMPLIANCE

This section compares applicable criteria with the above emplacement/retrieval system and component descriptions to show to what extent the criteria have been met and to identify criteria that need further proof. This comparison of system criteria is detailed in Table 13.

Table 13. Criteria Compliance

Criterion	Compliance Discussion
1.2.1.1	Specific calculations are made in "Bottom/Side Lift Gantry Conceptual Design" (Section 6.4.1) to demonstrate that the service life of the emplacement gantry lifting screw is greater than 40 years. Criterion is also met as a general requirement for the emplacement gantry in Section 7.2.3 of "Bottom/Side Lift Gantry Conceptual Design." Evaluation of this criterion has not been made for the other portions of the system that support emplacement.
1.2.1.2	Criterion is met in Sections 6.1.3 and 6.2.3 of "Retrieval Equipment and Strategy for WP on Pallet."
1.2.1.3	Criterion is met in Sections 6.1.3 and 6.2.3 of "Retrieval Equipment and Strategy for WP on Pallet," however, providing for 300 years of operation is more of a maintenance and equipment replacement issue than a design issue.
1.2.1.4	Criterion has been evaluated for previously identified throughput values. Compliance with the previous values was stated in Section 7.2.12 of "Bottom/Side Lift Gantry Conceptual Design." The present criterion has not yet been quantified, and thus has not yet been re-evaluated.
1.2.1.5	Criterion is met in Section 6.1.3 of "Retrieval Equipment and Strategy for WP on Pallet."
1.2.1.6	Emplacement of large numbers of WPs may be done with proper maintenance and component replacement as discussed in "Waste Package Transport and Transfer Alternatives" (Section 7.4.7). Although this revision of the system description document changes the number of WPs to be emplaced, the same general maintenance and replacement activities would be used to comply with this criterion. Calculations shown in "Bottom/Side Lift Gantry Conceptual Design," Section 6.4.1, show that certain system components exceed even the current criterion.
1.2.1.7	Although not specifically identified as a design input to a document, this criterion is met for normal recovery by meeting Criterion 1.2.1.6 above. Abnormal condition recovery has not been fully evaluated.
1.2.1.8	This criterion is met in "Bottom/Side Lift Gantry Conceptual Design," Section 7.2.8.
1.2.1.9	This criterion is met in "Bottom/Side Lift Gantry Conceptual Design," Section 7.2.8.
1.2.1.10	Accuracy of emplacement location has not yet been defined, thus this criterion has not been evaluated in detail. There are no mechanical limitations preventing accurate emplacement of WPs.
1.2.1.11	Although this criterion has not been evaluated in detail, the use of rail-mounted transport equipment accommodates this criterion ("Retrieval Equipment and Strategy for WP on Pallet," Section 6.1.3).
1.2.1.12	As outlined in Section 6.2.6 of "Retrieval Equipment and Strategy for WP on Pallet," a multi-purpose vehicle will provide capabilities for meeting this criterion.
1.2.1.13	As outlined in Section 6.2.6 of "Retrieval Equipment and Strategy for WP on Pallet," a multi-purpose vehicle and hauler will provide capabilities for meeting this criterion.
1.2.1.14	Criterion is met as described in Section 6.2.6 of "Retrieval Equipment and Strategy for WP on Pallet."
1.2.1.15	Criterion is met by the methods described in Section 6.2.6 of "Retrieval Equipment and Strategy for WP on Pallet."
1.2.1.16	This criterion is met as described in "Retrieval Equipment and Strategy" (Section 7.2.4) and in "Retrieval Equipment and Strategy for WP on Pallet" (Sections 6.2 and 6.3).
1.2.1.17	This criterion is met as discussed in Section 6.2.4 of "Retrieval Equipment and Strategy for WP on Pallet." This capability is especially advantageous during abnormal retrieval.
1.2.1.18	This criterion is met as described in Section 6.3.4 of "Retrieval Equipment and Strategy for WP on Pallet."
1.2.1.19	This criterion is not yet specifically addressed in the design of the emplacement/retrieval system. It will be investigated as design concepts are advanced to support the License Application. The principal area of concern is potential heat build-up within the transporter's shielded enclosure containing the WP during an off normal event where the WP may be enclosed for a longer than usual period. The WP is not enclosed in any other step of the emplacement/retrieval process.
1.2.1.20	While the capability to re-emplace WPs is inherent in the design of this system (from the portions of the system supporting emplacements), evaluation of this criterion has not been made to confirm that re-emplacement would be completed in the required timeframe.

Table 13. Criteria Compliance (Continued)

Criterion	Compliance Discussion
1.2.1.21	Criterion is met by minimizing pockets where fixed contamination build-up could occur and by other measures discussed in Section 6.3.4 of "Retrieval Equipment and Strategy for WP on Pallet."
1.2.1.22	The conceptual plan to meet this criterion is discussed in Section 6.2.4 of "Retrieval Equipment and Strategy for WP on Pallet."
1.2.1.23	The criterion is met as described in Section 6.2.6 of "Retrieval Equipment and Strategy for WP on Pallet."
1.2.1.24	The criterion has not been evaluated because the design is still at a conceptual level; it will be addressed as the design is advanced to support the License Application.
1.2.1.25	Criterion is met as described in Section 6.3.4 of "Retrieval Equipment and Strategy for WP on Pallet."
1.2.1.26	The criterion has not been evaluated because the design is still at a conceptual level; it will be addressed as the design is advanced to support the License Application.
1.2.2.1.1	Concepts for meeting this criterion are presented in Sections 6.7 and 6.8 of "Subsurface Transporter Safety Systems Analysis." Based in these concepts, the system design will show that the runaway event is beyond design basis (Section 7.1 of "Subsurface Transporter Safety Systems Analysis").
1.2.2.1.2	The WP transporter and emplacement gantry will be limited to the speed set by the criterion ("Bottom/Side Lift Gantry Conceptual Design," Section 6.5; "Subsurface Transporter Safety Systems Analysis," used throughout; and "Waste Package Transport and Transfer Alternatives," Section 6.4.6).
1.2.2.1.3	Criterion is met by restricting the height that the WP pallet is lifted to 810 mm ("Bottom/Side Lift Gantry Conceptual Design," Section 6.3).
1.2.2.1.4	It is met for retrieval operations as described in Section 6.2.4 of "Retrieval Equipment and Strategy for WP on Pallet." Recovery from abnormal events during emplacement operations would be handled in a similar manner.
1.2.2.1.5	The criterion is met by using brakes on the lifting screws that lock the load in a safe and sustainable position should a power failure occur and by control system and equipment redundancy ("Bottom/Side Lift Gantry Conceptual Design," Sections 6.4 and 6.6).
1.2.2.1.6	The emplacement gantry and WP transporter designs have been demonstrated to meet this criterion for design basis seismic events ("Bottom/Side Lift Gantry Conceptual Design," Section 6.3 and "Waste Package Transport and Transfer Alternatives," Section 6.4.5).
1.2.2.1.7	The criterion is met by using brakes on the lifting screws that lock the load in a safe and sustainable position should a power failure occur and by control system and equipment redundancy ("Bottom/Side Lift Gantry Conceptual Design," Sections 6.4 and 6.6).
1.2.2.1.8	Although not identified as a specific input, this criterion is met by the incorporation of restraints and spacers to immobilize the WP within the transporter ("Waste Package Transport and Transfer Alternatives," Section 6.4.6.5).
1.2.2.1.9	Criterion is met as described in Section 6.3.1 of "Retrieval Equipment and Strategy for WP on Pallet."
1.2.2.1.10	Criterion is met because principal abnormal retrieval equipment is battery-powered ("Retrieval Equipment and Strategy for WP on Pallet," Section 6.2.4) and supporting equipment such as forklifts could be powered by on-board batteries, or trailing electric cable, depending upon the quantities used ("Retrieval Equipment and Strategy", Section 7.2.6.2). Emplacement and normal retrieval equipment is electrically powered ("Bottom/Side Lift Gantry Conceptual Design," Section 6.6.1; "Subsurface Transporter Safety Systems Analysis'" Section 6.1.2; and "Waste Package Transport and Transfer Alternatives," Sections 6.3.1.5 and 6.4.6.4). No evaluation of diesel powered equipment has been completed, because the system design is still at a conceptual level, and no piece of equipment has been specified as only diesel engine powered.
1.2.2.2.1	This criterion is unevaluated because dummy WP design has not yet been conceptualized. It will be addressed as the design is advanced to support the License Application.
1.2.3.1	This criterion is met by providing adequate shielding for radiation protection of components ("Bottom/Side Lift Gantry Conceptual Design", Section 6.6.8).
1.2.3.2	Criterion is not yet addressed in the design of the emplacement/ retrieval system. It will be addressed as the design is advanced to support the License Application. The temperature environment, however, has very little effect upon the design of the locomotive and transporter according to "Mobile Waste Handling Support Equipment" (Section 8.3.7). Note: This criterion for the WHB is less extreme than Criterion 1.2.3.3 below.
1.2.3.3	This criterion is met in Section 7.3.3.6 of "Mobile Waste Handling Support Equipment" where it is used for sizing the transport locomotive cab heater and air conditioner.

Table 13. Criteria Compliance (Continued)

Criterion	Compliance Discussion
1.2.3.4	The low temperature is less extreme than Criterion 1.2.3.3 above and is met in “Mobile Waste Handling Support Equipment” (Section 7.3.3.6 and Section 8.3.7) for the locomotive and transporter and in “Bottom/Side Lift Gantry Conceptual Design” (Section 6.6.8) for the emplacement gantry.
1.2.3.5	This criterion is not yet addressed in the design of the emplacement/ retrieval system. It will be addressed as the design is advanced to support the License Application. The humidity environment, however, has very little effect upon the design of the locomotive and transporter (“Mobile Waste Handling Support Equipment,” Section 8.3.7).
1.2.3.6	This criterion is not yet addressed in the design of the emplacement/retrieval system. It will be addressed as the design is advanced to support the License Application. The humidity environment, however, has very little effect upon the design of the locomotive and transporter (“Mobile Waste Handling Support Equipment,” Section 8.3.7).
1.2.3.7	This criterion is not yet addressed in the design of the emplacement/ retrieval system. It will be addressed as the design is advanced to support the License Application. The humidity environment has very little effect upon the design of the locomotive and transporter (“Mobile Waste Handling Support Equipment,” Section 8.3.7) but may impact the design of the emplacement instrumentation.
1.2.3.8	This criterion is not yet addressed in the design of the emplacement/ retrieval system. It will be addressed as the design is advanced to support the License Application. The natural surface environment, however, has very little effect upon the design of the locomotive and transporter (“Mobile Waste Handling Support Equipment,” Section 8.3.7).
1.2.3.9	This criterion has not yet been addressed by including wind forces in the calculation of the overturning moment for the transporter and locomotives. It will be investigated as the design is advanced to support the License Application.
1.2.4.1	Criterion is yet to be demonstrated since the physical envelope is still TBD.
1.2.4.3	Compliance with this criterion is met for equipment operating on grades within an emplacement drift (“Preliminary Waste Package Transport and Emplacement Equipment Design,” Attachment V; and “Retrieval Equipment and Strategy,” Attachment I, Section 3.2) and for equipment operating on grades outside of an emplacement drift (“Preliminary Waste Package Transport and Emplacement Equipment Design,” Attachment VII).
1.2.4.4	Compliance with this criterion is met for equipment operating on grades within an emplacement drift (“Preliminary Waste Package Transport and Emplacement Equipment Design,” Attachment V; and “Retrieval Equipment and Strategy,” Attachment I, Section 3.2) but compliance has not yet been demonstrated by calculation for the maximum grade outside of an emplacement drift.
1.2.4.5	This interface criterion is met as illustrated in “Bottom/Side Lift Gantry Conceptual Design” (Figure 4) and “Waste Package Transport and Transfer Alternatives” (Figure 5).
1.2.4.6	Transporter trucks were selected to meet minimum curve radii criterion in “Waste Package Transport and Transfer Alternatives” (Section 6.4.7.1).
1.2.4.7	Criterion is met as shown in Figure 2 and Figure 4 of “Bottom/Side Lift Gantry Conceptual Design.”
1.2.4.8	Criterion is met for emplacement operations in Section 6.5 of “Bottom/Side Lift Gantry Conceptual Design.” Although not a specific input to “Retrieval Equipment and Strategy for WP on Pallet,” the criterion is met for retrieval operations because the same gantry is utilized for recovering WPs as for emplacing them.
1.2.4.9	Criterion is met as discussed in Section 7.2.4.9 of “Retrieval Equipment and Strategy.”
1.2.4.10	The emplacement gantry meets this criterion (“Bottom/Side Lift Gantry Conceptual Design,” Figure 10 and 7.2.5) but the WP transporter extends slightly outside the operating envelope for the north ramp curvature at a radius of 305 m (“Waste Package Transport and Transfer Alternatives,” Section 7.4.3).
1.2.4.11	This criterion is met as described in Section 6.6.1 of “Bottom/Side Lift Gantry Conceptual Design,” Section 6.1.3 of “Retrieval Equipment and Strategy for WP on Pallet,” Table 8 of “Retrieval Equipment and Strategy,” and Section 7.1.1 of “Preliminary Waste Package Transport and Emplacement Equipment Design” (note that the “DC Third Rail Power System” of the cited analysis has since been allocated to the Subsurface Emplacement Transportation System and is described in “Repository Rail Electrification Analysis”).
1.2.4.12	Use of this criterion is implicit in the recovery strategy outlined in Section 7.2.4.1 of “Retrieval Equipment and Strategy.”
1.2.4.13	Preliminary concepts for meeting this criterion are presented in Sections 6.6 through 6.8 of “Instrumentation and Controls for Waste Emplacement” as stated in Section 7 of the same document.
1.2.4.15	This criterion is met conceptually in Section 6.1 of “Bottom/Side Lift Gantry Conceptual Design,” but calculations need to be documented to support this conclusion once the surface dose rate is verified.

Table 13. Criteria Compliance (Continued)

Criterion	Compliance Discussion
1.2.4.16	This criterion is not specifically addressed as a design input to the emplacement/retrieval system, where key design parameters are weight and physical size. This criterion will be addressed for completeness as the design of this system is advanced to support the License Application.
1.2.4.17	Criterion is not yet addressed for all items in the emplacement/retrieval system. Principal handling equipment, such as the emplacement gantry ("Bottom/Side Lift Gantry Conceptual Design," Section 6.3) and the transporter ("Waste Package Transport and Transfer Alternatives," Sections 6.4.3, 6.4.4, and 6.4.5), have been evaluated and meet the criterion. Other items in the system will be evaluated as the design of the system is advanced.
1.2.4.18	It is met in Section 7.7 of "Preliminary Waste Package Transport and Emplacement Equipment Design" and as described in Section 6.1 of "Bottom/Side Lift Gantry Conceptual Design," Section 6.1.2.4 of "Retrieval Equipment and Strategy for WP on Pallet," and Section 6.1.1 of "Waste Package Transport and Transfer Alternatives."
1.2.4.19	Criterion has not yet been addressed as an input to the design of the emplacement/retrieval system. It will be incorporated as system design is advanced to support the License Application.
1.2.5.1	Due to the present conceptual nature of the design, a detailed design showing compliance with this criterion has not been completed. This will be accomplished as the design is advanced to support the License Application.
1.2.5.2	Due to the present conceptual nature of the design, a detailed design showing compliance with this criterion has not been completed. This will be accomplished as the design is advanced to support the License Application.
1.2.6.1	Due to the present conceptual nature of the design, a detailed code comparison with the emplacement/retrieval system has not been completed. This will be accomplished as the design is advanced to support the License Application.
1.2.6.2	Due to the present conceptual nature of the design, a detailed code comparison with the emplacement/retrieval system has not been completed. This will be accomplished as the design is advanced to support the License Application.
1.2.6.3	The manual has been used in section 6.3 of "Bottom/Side Lift Gantry Conceptual Design," in several attachments to "Preliminary Waste Package Transport and Emplacement Equipment Design (Attachment I, Section 4; Attachment II, Sections 2.4 and 5.1; and Attachment IV, Section 3.1), and in Waste Package Transport and Transfer Alternatives, Section 6.3.4
1.2.6.4	Due to the present conceptual nature of the design, a detailed standard comparison with the emplacement/retrieval system has not been completed. This will be accomplished as the design is advanced to support the License Application.
1.2.6.5	Due to the present conceptual nature of the design, a detailed standard comparison with the emplacement/retrieval system has not been completed. This will be accomplished as the design is advanced to support the License Application.
1.2.6.6	Due to the present conceptual nature of the design, a detailed standard comparison with the emplacement/retrieval system has not been completed. This will be accomplished as the design is advanced to support the License Application.
1.2.6.7	An earlier version of this code was used in Sections 7.3.3.1 and 7.4.3.1 of "Preliminary Waste Package Transport and Emplacement Equipment Design" (the most recent version of the code was not available at the time of the analysis).
1.2.6.8	The rule has been used in Sections 5.4, 6.4, and 6.5 of "Bottom/Side Lift Gantry Conceptual Design," in Section 7.4.3.3 and several attachments to "Preliminary Waste Package Transport and Emplacement Equipment Design (Attachment I, Section 5; Attachment II, Sections 6 and 7; and Attachment V, Section 2)
1.2.6.9	The specification has been used in several attachments to "Preliminary Waste Package Transport and Emplacement Equipment Design (Attachment I, Sections 1-4; Attachment II, Sections 1-8; and Attachment IV, Sections 2 and 3.5, Attachment V, Sections 2, 3.1, and 3.2; and Attachment VI, Section 3.2) and in "Waste Package Transport and Transfer Alternatives," Section 6.4.6.2.
1.2.6.11	Due to the present conceptual nature of the design, a detailed code comparison with the emplacement/retrieval system has not been completed. This will be accomplished as the design is advanced to support the License Application.
1.2.6.12	Applicable Controlled Project Assumptions have been considered in Section 5 of "Waste Package Transport and Transfer Alternatives," and Section 6.1 of "Bottom/Side Lift Gantry Conceptual Design."
1.2.6.13	Due to the present conceptual nature of the design, a detailed code comparison with the emplacement/retrieval system has not been completed. This will be accomplished as the design is advanced to support the License Application.

3. SYSTEM OPERATIONS

A system operations description for this system will be provided in a future revision.

4. SYSTEM MAINTENANCE

A system maintenance description for this system will be provided in a future revision.

APPENDIX A CRITERION BASIS STATEMENTS

This section presents the criterion basis statements for criteria in Section 1.2. Descriptions of the traces to "Monitored Geologic Repository Requirements Document" (MGR RD) and "Revised Interim Guidance Pending Issuance of New U.S. Nuclear Regulatory Commission (NRC) Regulations (Revision 01, July 22, 1999), for Yucca Mountain, Nevada" are shown as applicable. In anticipation of the interim guidance being promulgated as a Code of Federal Regulations, it will be referred to as "10 CFR 63" in this system description document.

1.2.1.1 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to support Section 5.3.6 of the "Monitored Geologic Repository Project Description.

II. Criterion Performance Parameter Basis

N/A

1.2.1.2 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the length of time that the portions of the system that support retrieval, recovery, and restoration need to be operable. This criterion is required because this system supports the waste handling operations at the repository as required by MGR RD 3.2.C. This criterion also supports the retrieval requirements of MGR RD 3.1.C. The system will not be in continuous operation during the entire time period, but the system will need to be designed to perform retrieval and recovery operations at any time during the operational period. In addition, this system supports Performance Confirmation, and this criterion establishes the minimum length of time the system will be needed to support Performance Confirmation operations. The system must continue operations until repository closure, as required by MGR RD 3.1.C. To meet the operational life requirement, system components may require replacement in addition to any required preventive maintenance program. This criterion supports Section 5.1.1.1 of the "Monitored Geologic Repository Project Description Document."

II. Criterion Performance Parameter Basis

The time period of 30 years after final waste package emplacement is taken from Section 5.1.1.1 of the "Monitored Geologic Repository Project Description Document."

1.2.1.3 Criterion Basis Statement

I. Criterion Need Basis

This criterion establishes the maximum length of time the system may be asked to operate to allow future generations to continue monitoring the repository. The system must continue operations until repository closure, as required by MGR RD 3.1.C, 10 CFR 63.111(d), 10 CFR 63.131(b), and 10 CFR 63.134(d). This criterion also supports the retrieval requirements of MGR RD 3.2.H, 3.1.C, and 10 CFR 63.111(e)(1). This criterion supports Section 5.1.1.1 of the "Monitored Geologic Repository Project Description Document."

II. Criterion Performance Parameter Basis

The life of 300 years after final WP emplacement is taken directly from Section 5.1.1.1 of the "Monitored Geologic Repository Project Description Document."

1.2.1.4 Criterion Basis Statement

I. Criterion Need Basis

This criterion defines the figure of merit for how fast the system has to emplace waste so that the overall MGR rates can be met. This criterion supports MGR RD 3.2.C and 3.2.E.

II. Criterion Performance Parameter Basis

N/A

1.2.1.5 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish the time period within which the system must retrieve all emplaced WPs to support MGR RD 3.2.J, 3.1.C, 10 CFR 63.111(e)(1), and 63.111(e)(3).

II. Criterion Performance Parameter Basis

The time period during which the system must retrieve all emplaced WPs is taken directly from MGR RD 3.2.J.

1.2.1.6 Criterion Basis Statement

I. Criterion Need Basis

This requirement establishes the minimum number of WPs that the system must be able to emplace and retrieve. This criterion responds to MGR RD 3.1.C, 3.2.C, and 10 CFR 63.111(e)(1).

II. Criterion Performance Parameter Basis

The maximum number of WPs that the system must be designed to emplace and retrieve is obtained from "Monitored Geologic Repository Project Description Document," Section 5.2.4. Addition of the WP quantity numbers in the rightmost column of the table accompanying Section 5.2.4 is a conservative bound for this value.

1.2.1.7 Criterion Basis Statement

I. Criterion Need Basis

This requirement establishes the minimum number of WPs that the system must be able to recover. It also establishes the role of the system to perform recovery of small numbers of selected WPs under normal and abnormal conditions. This criterion is different from the number of WPs to be retrieved because recovery may be conducted under much harsher conditions than retrieval, and the uses of alternate power sources may limit the effort spent in recovering a WP.

Also, this criterion establishes the ability of the system to support recovery of “dummy” WPs to support Performance Confirmation activities (as a lower level decomposition of 10 CFR 63.131(d)(3)). The need to recover “dummy” WPs is documented in “Performance Confirmation Plan,” Section 5.3.1.8.3. No special mention of “dummy” WPs is made in the criterion since there is no reason to believe that recovery of a “dummy” WP will be any different than recovery of a real WP.

This criterion responds to MGR RD 3.1.C, 10 CFR 63.111(d), 10 CFR 63.111(e)(1), and 10 CFR 63.131(d)(3).

II. Criterion Performance Parameter Basis

N/A

1.2.1.8 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish the emplacement mode. Horizontal in-drift emplacement of WPs is the reference design concept for the MGR.

II. Criterion Performance Parameter Basis

N/A

1.2.1.9 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to support line loading of WPs within emplacement drifts.

II. Criterion Performance Parameter Basis

The WP spacing is obtained from "Monitored Geologic Repository Project Description Document," Section 5.2.10.

1.2.1.10 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to support proper implementation of line loading as defined by the Emplacement Drift System. Placement of WPs too far away from the intended location could result in unacceptable temperature variations along the length of the emplacement drift.

II. Criterion Performance Parameter Basis

N/A

1.2.1.11 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to determine the location to which the system will transport retrieved WPs, in support of MGR RD 3.1.C and 10 CFR 63.111(e)(1)

II. Criterion Performance Parameter Basis

The location of the potential lag storage area that may support retrieval is obtained from "Repository Surface Design Site Layout Analysis," Attachment I, Figure 4. The distance, as shown on Figure 4, from the edge of the WHB to the farthest edge of the Potential On-site Storage Area is approximately 2 miles. The unverified value used in this criterion is rounded up to 2.5 miles to account for limited deviations in the location of the WHB, the location of the potential storage area, and the path by which the system would traverse the distance.

1.2.1.12 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the capability of the system to support recovery operations. Failed ground support and rockfall are conditions that would lead to initiation of recovery operations.

II. Criterion Performance Parameter Basis

N/A

1.2.1.13 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the capability of the system to support recovery operations. Failed ground support and rockfall are conditions that would lead to initiation of recovery operations.

II. Criterion Performance Parameter Basis

N/A

1.2.1.14 Criterion Basis Statement

I. Criterion Need Basis

This criterion supports the requirement to maintain the option of retrievability as specified in MGR RD 3.1.C, and 10 CFR 63.111(e)(1), and also supports the recovery of a WP after a failure in the ground support.

II. Criterion Performance Parameter Basis

N/A

1.2.1.15 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the capability of the system to support recovery operations. Failed ground support and rockfall are conditions that would lead to initiation of recovery operations. Partial or full occlusion (and accompanying reduced ventilation) of the emplacement drift at some point in its length may result from the ground support failure and rockfall.

II. Criterion Performance Parameter Basis

N/A

1.2.1.16 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the capability of the system to support recovery operations. An abnormal event may damage the ability of the Subsurface Emplacement Transportation System to provide adequate rail and power up to the WP to be recovered, and may also damage the ability of the Site Communications System to provide communications for remote control of the system.

II. Criterion Performance Parameter Basis

N/A

1.2.1.17 Criterion Basis Statement

I. Criterion Need Basis

This requirement is needed to ensure that recovery operations may be conducted even if access to the WPs to be recovered from the normal entrance to the emplacement drift is not practical. It should be noted that the emplacement drift in the current design is the tunnel between the emplacement drift isolation doors and the ventilation raise. Thus, this criterion requires the capability to recover WPs from the end of the emplacement drift with the ventilation raise, which would require crossing over the ventilation raise in the current design.

This criterion is derived from “Retrievability Strategy Report,” Section 8.2.1.1.

II. Criterion Performance Parameter Basis

N/A

1.2.1.18 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the capability of the system to support recovery operations. A breached WP is one of the conditions that would lead to initiation of recovery operations. This criterion is intended to limit the spread of contamination during the transfer of a breached or contaminated WP to the surface. This criterion responds to MGR RD 3.1.C, 3.1.G, and 10 CFR 63.112(e)(1).

This criterion is supported by guidance contained in the “MGR Compliance Program Guidance Package for the Waste Emplacement System,” Guidance Statement 6.6g6, and “MGR Compliance Program Guidance Package for the Waste Retrieval System,” Guidance Statement 6.6g6.

II. Criterion Performance Parameter Basis

N/A

1.2.1.19 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the capability of the system needed to support emplacement, retrieval, and recovery operations. Heat removal from the WP is essential to maintaining the waste forms below their temperature limits. This criterion supports MGR RD 3.2.L.

II. Criterion Performance Parameter Basis

The maximum temperature value for zircaloy clad spent nuclear fuel was established in “Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada,” Section 7.2.1.3.3. This number was reaffirmed in “Site Characterization Plan Thermal Goals Reevaluation,” p. 20; and again in “Thermal Loading Study for FY 1996,” Section 7, p. 7-7.

The maximum temperature value for vitrified high-level waste is consistent with the higher limit (500 degrees C) established in “Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada,” Section 7.2.1.3.3. The higher limit was reaffirmed in “Site Characterization Plan Thermal Goals Reevaluation,” p. 20. However, the “Waste Acceptance System Requirements Document,” Section 4.2.3.1.G.1, conservatively reduces the temperature limit to the value shown in the criterion, and imposes a stability requirement on the producers of vitrified high-level waste.

The other values have not yet been determined.

1.2.1.20 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure that WPs that are moved to enable recovery or retrieval of another WP are re-emplaced.

Also, this criterion establishes the ability of the system to support emplacement of “dummy” WPs to support Performance Confirmation activities (as a lower level decomposition of MGR RD 3.1.C, 10 CFR 63.111(d), and 10 CFR 63.131(d)(3)). The need to emplace “dummy” WPs is documented in “Performance Confirmation Plan,” Section 5.3.1.8.3. No special mention of “dummy” WPs is made in the criterion since there is no reason to believe that emplacement of a “dummy” WP will be any different than emplacement of a real WP.

II. Criterion Performance Parameter Basis

N/A

1.2.1.21 Criterion Basis Statement

I. Criterion Need Basis

This criterion reduces the accumulation of fixed contamination and supports radiological safety for personnel. This criterion supports MGR RD 3.1.G and 3.3.A.

This criterion is supported by guidance contained in the “MGR Compliance Program Guidance Package for the Waste Emplacement System,” Guidance Statements 6.6g3, 6.6g5, 6.7g3, and 6.7g5; and “MGR Compliance Program Guidance Package for the Waste Retrieval System,” Guidance Statements 6.6g3, 6.6g5, 6.7g3, and 6.7g5.

II. Criterion Performance Parameter Basis

N/A

1.2.1.22 Criterion Basis Statement

I. Criterion Need Basis

This criterion establishes the role of the system to aid in the restoration of the system after an abnormal event. Derailment is one of the possible events that would disable the system. This criterion supports MGR RD 3.1.G.

This criterion is supported by guidance contained in the “MGR Compliance Program Guidance Package for the Waste Emplacement System,” Guidance Statement 6.6g6; and “MGR Compliance Program Guidance Package for the Waste Retrieval System,” Guidance Statement 6.6g6.

II. Criterion Performance Parameter Basis

N/A

1.2.1.23 Criterion Basis Statement

I. Criterion Need Basis

This criterion establishes the role of the system to aid in the restoration of the system after an abnormal event. Derailment is one of the possible events that would disable the system. This criterion is intended to cover the derailment events that are not covered in the previous criterion. This criterion supports MGR RD 3.1.G.
This criterion is supported by guidance contained in the “MGR Compliance Program Guidance Package for the Waste Emplacement System,” Guidance Statement 6.6g6; and “MGR Compliance Program Guidance Package for the Waste Retrieval System,” Guidance Statement 6.6g6.

II. Criterion Performance Parameter Basis

N/A

1.2.1.24 Criterion Basis Statement

I. Criterion Need Basis

The tracks that the system will use are located underground. Loose rock and ground support materials are likely to fall from the roof over time as the repository ages and ground support measures deteriorate. Furthermore, much of the track is in sections that will be accessed infrequently. Without frequent traffic, debris is likely to build up. Loose rock and other debris on the track or in the flange-way next to the track may cause derailments. Derailments can result whenever debris causes a wheel to be lifted off the rail far enough to allow the flange to clear or ride over the top of the rail. This lifting can occur if the wheel surface encounters a piece of debris small enough to become wedged under the wheel. It can also occur if the edge of the flange rides up on a piece of debris.

This criterion is needed to ensure that loose rock that may accumulate on or near the rails will not derail the system.

II. Criterion Performance Parameter Basis

1. Minimum Debris Size Clearing

A derailment is not likely unless the wheel is lifted the depth of the flange. Applying a safety factor of 2, any obstruction less than one-half the depth of a flange should not present a derailment hazard.

Examination of “Manual of Standards and Recommended Practices Section G -- Wheels and Axles” (Figures 9 and 10 of Specifications M-107-84 and M-208-84, freight car and locomotive standard wheels; and Standard S-657-81, passenger car wheel) indicates that a flange height of 1 in. is consistently used for all standard wheels. Thus, the system should be able to clear debris a minimum of 0.5 in. from the top of the rail and the flange-way in front of the system rail mounted equipment as the equipment moves forward.

2. Maximum Debris Size Clearing

A derailment is not likely if the debris is so big that the wheel will tend to push the debris rather than ride up on it. The wheel cannot ride up on the debris if the top of the debris is above the center of the wheel.

The largest wheel size chosen for the system will drive the largest debris to be cleared from the tracks, since any smaller wheel encountering the debris would tend to push the debris rather than ride up on it, as mentioned above. Examination of “Manual of Standards and Recommended Practices Section G -- Wheels and Axles” (Figures 9 and 10 of Specifications M-107-84 and M-208-84, freight car and locomotive standard wheels; and Standard S-657-81, passenger car wheel) and “Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes” (Table 4.13.3-4) indicates that the largest standard wheel is a locomotive wheel 42 in. in diameter. Thus, the system should be designed to clear debris from the rail with a maximum size of 21 in.

1.2.1.25 Criterion Basis Statement

I. Criterion Need Basis

This criterion establishes the role of the system to decontaminate the underground after an abnormal event.

II. Criterion Performance Parameter Basis

Existing standards for levels at which areas are decontaminated are chosen for use in this criterion from the "Radiological Control Manual," Section 222. Allowances for the use of fixative coatings for areas that cannot be properly decontaminated are also supported in Section 222 and are included here to recognize that all areas may not be able to be adequately decontaminated.

1.2.1.26 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the capability of the system needed to support emplacement, retrieval, and recovery operations. Heat removal from the WP is essential to maintaining the waste forms below their temperature limits. This criterion supports MGR RD 3.2.L.

II. Criterion Performance Parameter Basis

The heat flux parameters are taken from Table 6 of "Thermal, Shielding, and Structural Information on the Naval Spent Nuclear Fuel (SNF) Canister." The allowable heat flux at high surface temperatures is a function of the canister surface temperature and will be provided by the Naval Nuclear Propulsion Program. The lower temperature heat flux parameters do not need confirmation, per "Memorandum of Agreement for Acceptance of Naval Spent Nuclear Fuel," Appendix E, wherein the Department of Energy, Office of Civilian Radioactive Waste Management agrees to accept Naval Nuclear Propulsion Program generated data as qualified data.

1.2.2.1.1 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to prevent damage to a loaded WP as a result of a runaway WP transporter, which could result in a radiological release. This criterion supports the implementation of MGR RD 3.1.C, 10 CFR 63.111(a)(2), 10 CFR 63.111(b)(2), and 10 CFR 63.112(e)(8).

This criterion implements a portion of the safety strategy as described in "Decision Package Executive Summary, Strategy to Mitigate Preclosure Offsite Exposure," Description IV of Options 1 and 2. The executive summary is an attachment to interoffice correspondence "Strategy to Mitigate Preclosure Offsite Exposure," and is controlled by input transmittal "Strategy to Mitigate Preclosure Offsite Exposure" (RSO-RSO-99352.T). A portion of that safety strategy is to avoid the occurrence of design basis events by specifically designing the system (WP transporter and locomotives) to prevent accidents during the transport of WPs from the WHB to the emplacement drifts.

The general wording for this criterion was obtained from "Safety Criteria for SDD SS-17, Waste Emplacement System." This criterion is intended to address criteria 1.2.2.1 and 1.2.2.4 of Attachment 1.

II. Criterion Performance Parameter Basis

Under the current design concept, an uncontrolled descent of a WP transporter carrying a WP down the North Ramp of the repository would result in a top speed of the transporter of 63 km/hr at the bottom of the ramp (Table 7.3-1 of "Waste Package Design Basis Events"). Potential derailment of the transporter at such speeds could damage the WP. This criterion conservatively bounds the upper limit of the probability of such an initiating event to less than 10^{-6} events/year to categorize it as an incredible event (if it is not shown to be incredible, specific features must be incorporated to mitigate the impact of the event on the WP to within its design limits), as described in Table 9 of "Preliminary Selection of MGR Design Basis Events."

1.2.2.1.2 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to prevent damage to a loaded WP as a result of a derailed WP transporter that could result in a radiological release. This criterion supports the implementation of MGR RD 3.1.C, 10 CFR 63.111(a)(2), 10 CFR 63.111(b)(2), and 10 CFR 63.112(e)(8).

This criterion implements a portion of the safety strategy as described in "Decision Package Executive Summary, Strategy to Mitigate Preclosure Offsite Exposure," Description IV of Options 1 and 2. The executive summary is an attachment to "Strategy to Mitigate Preclosure Offsite Exposure," and is controlled by input transmittal "Strategy to Mitigate Preclosure Offsite Exposure" (RSO-RSO-99352.T). A portion of that safety strategy is to avoid the occurrence of Design Basis Events by specifically designing the system (WP transporter and locomotives) to prevent accidents during the transport of WPs from the WHB to the emplacement drifts.

II. Criterion Performance Parameter Basis

The maximum speed of 8 km/hr is obtained from Section 7 of "Subsurface Transporter Safety Systems Analysis."

1.2.2.1.3 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to prevent the WP from being subjected to a drop greater than the height in which the WP design was evaluated against. A drop exceeding the criterion, although unevaluated, could potentially result in a WP breach and subsequent radiological release. This criterion supports the implementation of MGR RD 3.1.C, 10 CFR 63.111(a)(2), 10 CFR 63.111(b)(2), and 10 CFR 63.112(e)(8).

This criterion implements a portion of the safety strategy as described in “Decision Package Executive Summary, Strategy to Mitigate Preclosure Offsite Exposure,” Description V of Options 1 and 2. The executive summary is an attachment to “Strategy to Mitigate Preclosure Offsite Exposure,” and is controlled by input transmittal “Strategy to Mitigate Preclosure Offsite Exposure” (RSO-RSO-99352.T). A portion of that safety strategy is to not lift the WP above its design basis height.

The basis for this criterion was obtained from “Safety Criteria for SDD SS-17, Waste Emplacement System.” This criterion is intended to address criterion 1.2.2.12 of Attachment 1.

II. Criterion Performance Parameter Basis

The values for the drop heights listed in this criterion are obtained from “Waste Package Design Basis Events,” Table 8-1. The Disposal Container systems use the same values in their design. These values may also be found in “Safety Criteria for SS-17, Waste Emplacement System,” criteria 1.2.2.12 of Attachment 1.

1.2.2.1.4 Criterion Basis Statement

I. Criterion Need Basis

This criterion identifies recovery features for abnormal and design basis events. This criterion supports the implementation of MGR RD 3.1.C, 3.1.G, 10 CFR 63.111(a)(2), 10 CFR 63.111(b)(2), and 10 CFR 63.112(e)(8).

This criterion is supported by guidance contained in the “MGR Compliance Program Guidance Package for the Waste Emplacement System,” Guidance Statement 6.6g6; and “MGR Compliance Program Guidance Package for the Waste Retrieval System,” Guidance Statement 6.6g6.

II. Criterion Performance Parameter Basis

N/A

1.2.2.1.5 Criterion Basis Statement

I. Criterion Need Basis

This criterion identifies the need to provide emergency shutdown capability. This criterion implements MGR RD 3.1.C, 3.1.G, and 10 CFR 63.112(e)(10).

The basis for this criterion was obtained from "Safety Criteria for SDD SS-17, Waste Emplacement System." This criterion is intended to address criterion 1.2.2.10 of Attachment 1.

This criterion is supported by guidance contained in the "MGR Compliance Program Guidance Package for the Waste Emplacement System," Guidance Statement 6.6g6; and "MGR Compliance Program Guidance Package for the Waste Retrieval System," Guidance Statement 6.6g6.

II. Criterion Performance Parameter Basis

N/A

1.2.2.1.6 Criterion Basis Statement

I. Criterion Need Basis

This criterion supports the implementation of MGR RD 3.1.C, 3.1.G, 10 CFR 63.111(a)(2), 10 CFR 63.111(b)(2), and 10 CFR 63.112(e)(8).

This criterion is supported by guidance contained in the "MGR Compliance Program Guidance Package for the Waste Emplacement System," Guidance Statement 6.7g6; and "MGR Compliance Program Guidance Package for the Waste Retrieval System," Guidance Statement 6.7g6.

II. Criterion Performance Parameter Basis

N/A

1.2.2.1.7 Criterion Basis Statement

I. Criterion Need Basis

This criterion identifies the need to maintain control of the WP during credible design basis events. This criterion implements MGR RD 3.1.C, 10 CFR 63.111(a)(2), 10 CFR 63.111(b)(2), and 10 CFR 63.112(e)(8).

II. Criterion Performance Parameter Basis

N/A

1.2.2.1.8 Criterion Basis Statement

I. Criterion Need Basis

This criterion identifies the need to maintain control of the WP during credible design basis events. Retention within the WP transporter will reduce the occupational dose associated with restoring the system and associated systems after such an event, and it will protect the WP from direct impacts with other non-system SSCs. This criterion implements MGR RD 3.1.C, 3.1.G, and 10 CFR 63.112(e)(10).

This criterion is supported by guidance contained in the "MGR Compliance Program Guidance Package for the Waste Emplacement System," Guidance Statement 6.7g6; and "MGR Compliance Program Guidance Package for the Waste Retrieval System," Guidance Statement 6.7g6.

II. Criterion Performance Parameter Basis

N/A

1.2.2.1.9 Criterion Basis Statement

I. Criterion Need Basis

MGR RD 3.1.C requires compliance with 10 CFR 63. MGR RD 3.1.B and 10 CFR 63.111(a)(1) require compliance with "Standards for Protection Against Radiation" (10 CFR 20). Section 1101(b) of 10 CFR 20 states: "The licensee shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to the members of the public that are as low as is reasonably achievable (ALARA)."

Compliance with "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low as is Reasonably Achievable" (Regulatory Guide 8.8), is invoked because this regulatory guide is one of the primary regulatory documents that addresses ALARA and is acceptable to the U.S. Nuclear Regulatory Commission. This regulatory guide provides guidelines on achieving the occupational ALARA goals during the planning, design, and operations phases of a nuclear facility. According to Section B of this guide, "Effective design of facilities and selection of equipment for systems that contain, collect, store, process, or transport radioactive material in any form will contribute to the effort to maintain radiation doses to station personnel ALARA." Section C.2 addresses facility and equipment design features. The design process of each system must include an evaluation of the applicable requirements in Section C.2 of Regulatory Guide 8.8.

In addition to compliance with the applicable guidelines in Regulatory Guide 8.8, the design of the system must meet the project ALARA program goals. The project ALARA program will include both qualitative and quantitative goals. Regarding the ALARA program of a licensee, Section C.1.a(2) of Regulatory Guide 8.8 states: "The policy and commitment should be reflected in written administrative procedures and instructions for operations involving potential exposures of personnel to radiation and should be reflected in station design features. Instructions to designers, constructors, vendors, and station personnel specifying or reviewing station features, systems, or equipment should reflect the goals and objectives to maintain occupational radiation exposures ALARA."

This criterion supports MGR RD 3.1.G and is supported by guidance contained in the "MGR Compliance Program Guidance Package for the Waste Emplacement System," Guidance Statements 6.8g1 and 6.9g1; and "MGR Compliance Program Guidance Package for the Waste Retrieval System," Guidance Statements 6.8g1 and 6.9g1.

II. Criterion Performance Parameter Basis

N/A

1.2.2.1.10 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure that unacceptable levels of hydrocarbons are not accumulated in the underground. Hydrocarbons may support microbial life in the underground that may be detrimental to natural and engineered barrier performance. It is intended that the subsurface use of diesel-powered equipment be limited to emergencies, the repair of the Subsurface Electrical Distribution System, or if the Subsurface Emplacement Transportation System is not available.

II. Criterion Performance Parameter Basis

N/A

1.2.2.2.1 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to safely recover Performance Confirmation "dummy" WPs that will be instrumented and powered ("Performance Confirmation Plan," Section 5.3.1.8.3). The "dummy" WPs will, in some cases, have internal heaters to simulate WP heat output environment. Attempted recovery of an instrumented, energized "dummy" WP would create an unsafe condition.

II. Criterion Performance Parameter Basis

N/A

1.2.3.1 Criterion Basis Statement

I. Criterion Need Basis

Radiation from fuel assemblies, high-level waste canisters, or other radioactive sources can affect electrical and electronic components. Accumulated doses of radiation (also referred to as Total Integrated Dose) can cause eventual degradation of components containing organic compounds, such as electrical insulation and lubricants. Accumulated doses can also cause damage to components containing polymers. In addition to the material degradation issue, real-time operation of an electronic device may be compromised by the type of radiation it receives, such as neutrons colliding with the lattice atoms of the semiconductor.

Most of the electronic and electrical components will be located in mild environments with small radiation doses. Components that will be installed in radiation environments should be evaluated for the radiation doses that they can receive, and, where applicable, susceptibility to the type of radiation (X-ray, Gamma, neutron) should also be considered.

Shielding, distance, and duration of exposure can significantly reduce the radiation dose and type of radiation that a component receives. Therefore, detailed analyses on a case by case basis will determine the economic feasibility and practicability of providing shielding, distance from the source, minimizing exposure time, frequent replacement of the affected component, or qualification of the component for the radiation environment.

It should be emphasized that this criterion addresses the radiation doses that can affect operability of the components during normal operations, and is not intended to invoke environmental qualification requirements for post-accident operability.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

N/A

1.2.3.2 Criterion Basis Statement

I. Criterion Need Basis

Temperature can directly affect the performance or result in advanced degradation of a component. To ensure proper performance, many equipment manufacturers specify the normal temperature environment in which the component must operate. Manufacturers may also specify the maximum off-normal temperature environment that the components can be exposed to or operate in for a limited time. The off-normal condition may be caused by loss of electric power or failure of the ventilation system.

This criterion supports MGR RD 3.3.A

II. Criterion Performance Parameter Basis

Temperature values are based on Criterion 1.2.1.1 of “Waste Handling Building Ventilation System Description Document.”

1.2.3.3 Criterion Basis Statement

I. Criterion Need Basis

Temperature is considered to be one of the primary environmental parameters that can affect component performance or result in advanced degradation. To ensure proper performance, many equipment manufacturers specify the temperature environment in which the component must operate. This criterion establishes the outdoor temperature environment in which SSCs are expected to operate.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

The extreme outside temperature range of -15 degrees C to 47 degrees C is based on the annual extreme minimum and maximum temperatures for the nine meteorological monitoring sites located in the Yucca Mountain area. Locations of the nine sites are shown in Figure 2-1 of the “Engineering Design Climatology and Regional Meteorological Conditions Report.” Extreme temperatures (and other data) are in Tables A-1 through A-9 of this report.

The collected temperature data in Tables A-1 through A-9 are based on 11 years of monitoring at Sites 1 through 5 and four years of monitoring at Sites 6 through 9. Site 1 data are typically more representative of the nine sites because it is closest to the repository. However, due to the limited number of years that data were collected, the lowest and highest recorded temperatures for all nine sites are used to bound the extreme temperature range. Site 5 has the lowest recorded temperature of -13.1 degrees C and Site 9 has the highest of 45.1 degrees C. This temperature range was conservatively expanded to -15 degrees C to 47 degrees C.

1.2.3.4 Criterion Basis Statement

I. Criterion Need Basis

Temperature is considered to be one of the primary environmental parameters that can affect component performance or result in advanced degradation. To ensure proper performance, many equipment manufacturers specify the temperature environment in which the component must operate. This criterion establishes the subsurface temperature environment in which SSCs are expected to operate.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

The extreme subsurface temperature minimum is bounded by the natural underground air temperature data measured from the ESF and documented in "Underground Temperature Data Aug 95 to Jan 97 for STA 1+70, 7+54 & 28+26 - IOC.013" (controlled by input transmittal "Underground Temperature Data"). The values used for the entire subsurface are based on the measurement from station 1+70. This station was used because it bounds the lowest values for the entire ESF.

The extreme subsurface temperature maximum is based on Performance Criterion 1.2.1.4 of the "Subsurface Ventilation System Description Document."

1.2.3.5 Criterion Basis Statement

I. Criterion Need Basis

Humidity can affect performance of computers, electronic, electrical, and mechanical components. Low humidity may result in static discharge in electrical and electronic equipment. High humidity can result in advanced corrosion or biological growth within the component. High humidity may also affect the operation of recorders that use paper. High humidity is not expected to be a major concern at the MGR due to the generally dry climate; however, depending on the nature of the operations, some areas may exhibit high humidity conditions. To ensure proper performance, many equipment manufacturers specify the humidity environment in which the component must operate. This criterion establishes the indoor humidity environment in which components are expected to operate based on the intended installation location.

Humidity is not controlled during off-normal conditions because of the generally mild humidity environment at the repository, and the expected short-term duration of off-normal conditions, such as loss of power or ventilation system failure.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

Humidity values for occupied areas and electronics equipment areas are based on Criterion 1.2.1.2 of "Waste Handling Building Ventilation System Description Document."

1.2.3.6 Criterion Basis Statement

I. Criterion Need Basis

Humidity is considered to be a primary environmental parameter that can affect SSCs performance and anticipated life expectancy. This criterion establishes the surface external humidity environment at the site.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

The humidity values are taken from the “Engineering Design Climatology and Regional Meteorological Conditions Report,” Table A-1, Management and Operating Contractor Radiological and Environmental Field Programs Department Site 1 (NTS-60). Using Site 1 data is appropriate because the site is the closest and most representative of the North Portal, South Portal, and ventilation shafts. The annual mean humidity for Site 1 is 28 percent, which is the average of the yearly averages for each of the time periods (Hour 0400, 1000, 1600, 2200) (from Table A-1). The minimum summer mean humidity for Site 1 is 13 percent, which occurred in the month of June at hour 1600 (from Table A-1). The maximum winter mean humidity for Site 1 is 46 percent (rounded up from 45.9), which occurred in the month of December at hour 0400 (from Table A-1).

1.2.3.7 Criterion Basis Statement

I. Criterion Need Basis

Humidity is considered to be a primary environmental parameter that can affect SSCs performance and anticipated life expectancy. This criterion establishes the subsurface humidity environment at the site.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

N/A

1.2.3.8 Criterion Basis Statement

I. Criterion Need Basis

Daily precipitation is an environmental parameter that can affect system weatherproofing. This criterion establishes the rainfall rates through which the affected systems must be able to endure and function.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

The maximum annual precipitation is derived from the “Engineering Design Climatology and Regional Meteorological Conditions Report,” p. 4-10 and Figure 4-3. The report identifies a maximum annual precipitation that ranges from 1 to 10 in. for the period of 1949 to 1995. The bounding maximum annual precipitation of 10 in. is taken from the Amargosa Farms site. The Amargosa Farms site is deemed appropriate in the report based on its proximity to Yucca Mountain, p. 2-5, second paragraph.

The maximum daily precipitation is derived from the “Engineering Design Climatology and Regional Meteorological Conditions Report,” p. 4-21, fourth paragraph. The reference paragraph states, "The conclusion from the statistical analyses of observed and estimated precipitation data performed for this report indicate that the maximum daily precipitation within 50 km of Yucca Mountain is not expected to exceed five inches."

1.2.3.9 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure that the wind load on the system does not cause overturning or derailment of a loaded WP transporter.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

The maximum wind speed is obtained from "MGR Design Basis Extreme Wind/Tornado Analysis," Section 7.

1.2.4.1 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the operating envelope interface between the surface facilities and this system.

II. Criterion Performance Parameter Basis

N/A

1.2.4.3 Criterion Basis Statement

I. Criterion Need Basis

The criterion is needed to establish the maximum grade the portions of the system supporting emplacement must be designed to traverse while transporting WPs.

II. Criterion Performance Parameter Basis

Grade limitations for emplacement operations on the surface are established as an interface in the "Monitored Geologic Repository Site Layout System Description Document," Criterion 1.2.4.9. Grade limitations for the subsurface are established in the following criterion basis statement analysis. It should be noted that the grade limit for the surface (2.5 percent) is identical to the limit established in the following analysis for areas between the surface and the entrance to the emplacement drift.

Criterion Basis Statement Analysis: Maximum Grades

Purpose

The purpose of this analysis is to identify the maximum grades that the portions of the system supporting emplacement must operate upon, while moving WPs by rail from the MGR surface to the point of emplacement inside the emplacement drifts.

Assumptions

1. The maximum grade that the system will have to travel over to transport and emplace WPs will be in the ramps that access the subsurface repository.

Rationale: The ramps, which are already constructed, must be inclined to allow access from the subsurface repository to the surface repository. There is no compelling reason for the rest of the MGR that the system will be travelling on to be inclined at a grade greater than the ramps.

2. The system will use the North Ramp exclusively to access the subsurface repository.

Rationale: This assumption is based on the current layout for the surface repository ("Repository Surface Design Site Layout Analysis"), which shows the waste handling facilities adjacent to the North Portal in Attachment I, Figure 4. The location of the waste handling facilities near the North Portal has been a long-standing project assumption.

3. The maximum grade in emplacement drifts will be 0.5 percent.

Rationale: A slight grade in emplacement drifts is desired to allow gravity drainage of the drifts; however, excessive grades are unnecessary and complicated to implement. The value for this assumption is based on the most current layout for the subsurface repository. Therefore, the maximum grade will be 0.5 percent, as documented in Section 4.3.16 of the "Repository Subsurface Layout Configuration Analysis."*

Criteria Analysis

1. Grades in the North Ramp. The "ESF Layout Calculation" identifies the design of the ESF including details of the ESF drift grades. From Figure 3, the existing North Ramp grades are +2.0000 percent from the surface to North Portal, and -2.1486 percent from the North Portal to the main drift. Thus, the maximum grade that the system will encounter should be +/-2.1486 percent, and rounding this grade to +/-2.5 percent provides a conservative margin for the maximum expected grade to be traversed by the system. A limitation for the grade is an important factor in the sizing of the transport locomotives for the current waste emplacement concept. Thus, the design grade for the rail-based transportation system is limited to 2.5 percent, maximum.

2. Grades in Mains. Figure 3 of the "ESF Layout Calculation" identifies the grade of the existing east main as +/-1.3500 percent. Mains that the system must travel over and which have yet to be excavated will have slopes of up to +/-2.1846 percent, as documented in "Subsurface Repository Slopes,"* Table 8-1. Therefore, rounding this grade to +/-2.5 percent provides a conservative margin for the maximum expected grade to be traversed by the system.

3. Grades in Emplacement Drifts. As assumed previously, the "Repository Subsurface Layout Configuration Analysis"* identifies the grades/slope of all future emplacement drifts at +/-0.5 percent. Therefore, rounding this grade to +/-1.0 percent provides a conservative margin for the maximum expected grade to be traveled by the system within emplacement drifts.

Conclusion

Grades for the North Ramp and mains will not exceed +/-2.5 percent. Grades in the emplacement drifts will not exceed +/-1.0 percent.

However, in the event that the grades/slopes provided in the above Criteria Analysis require a change or increase in excess of the present maximum grades/slopes, this change would not invalidate the present concept for the system. But, it may require additional and/or larger transport locomotives to move the transporter through the ramps and drifts, and it may require larger drive units for the emplacement gantry in the emplacement drifts.

The use of unqualified input [marked *] in this analysis was necessary to establish the bounding characteristics for the design criteria. The inclusion of this input does not disqualify the results of the analysis due to the conservative margin used in establishing the bounding design criteria. Additionally, the bounding design criteria do not affect nuclear safety.

1.2.4.4 Criterion Basis Statement

I. Criterion Need Basis

The criterion is needed to establish the maximum grade the portions of the system supporting recovery, restoration, or retrieval must be designed to traverse.

II. Criterion Performance Parameter Basis

Grade limitations for retrieval, recovery, and restoration operations on the surface are established as an interface in the "Monitored Geologic Repository Site Layout System Description Document," Criterion 1.2.4.10. Grade limitations for the subsurface are established in the following criterion basis statement analysis. It should be noted that the grade limit for the surface (2.7 percent) is identical to the limit established in the following analysis for areas between the surface and the entrance to the emplacement drift.

Criterion Basis Statement Analysis: Maximum Grades

Purpose

The purpose of this analysis is to identify the maximum grades that the portions of the system supporting retrieval, recovery, and restoration must operate upon, while moving

WPs by rail from the point of emplacement inside the emplacement drift's surface to the surface.

Assumptions

1. The maximum grade that the system will have to travel over to transport and emplace WPs will be in the ramps that access the subsurface repository.

Rationale: The ramps, which are already constructed, must be inclined to allow access from the subsurface repository to the surface repository. There is no compelling reason for the rest of the MGR that the system will be travelling on to be inclined at a grade greater than the ramps.

2. The system will use either the North Ramp or the South Ramp to access the subsurface repository.

Rationale: This assumption is based on the idea that system activities may be initiated by an event that has rendered the North Ramp (the ramp that has been chosen for all waste emplacement activities) unusable.

3. The maximum grade in emplacement drifts will be 0.5 percent.

Rationale: A slight grade in emplacement drifts is desired to allow gravity drainage of the drifts; however, excessive grades are unnecessary and complicated to implement. The value for this assumption is based on the most current layout for the subsurface repository. Therefore, the maximum grade will be 0.5 percent, as documented in Section 4.3.16 of the "Repository Subsurface Layout Configuration Analysis."*

Criteria Analysis

1. Grades in the North Ramp. The "ESF Layout Calculation" identifies the design of the ESF including details of the ESF drift grades. From Figure 3, the existing North Ramp grades are +2.0000 percent from the surface to the North Portal, and -2.1486 percent from the North Portal to the main drift. Also from Figure 3, the existing South Ramp grades are +2.00 percent from the surface to the South Portal, and -2.6189 percent from the South Portal to the main drift. Thus, the maximum grade that the system will encounter should be +/-2.6189 percent, and rounding this grade to +/-2.7 percent provides a margin for the maximum expected grade to be traversed by the system. A limitation for the grade is an important factor in the sizing of the transport locomotives for the current system concept. Thus, the design grade for the rail-based transportation system is limited to +/-2.7 percent, maximum.

2. Grades in Mains. Figure 3 of the "ESF Layout Calculation" identifies the grade of the existing east main as +/-1.3500 percent. Mains that the system must travel over and which have yet to be excavated will have slopes of up to +/-2.1846 percent, as documented in "Subsurface Repository Slopes,"* Table 8-1. Therefore, rounding this grade to +/-2.7 percent provides a conservative margin for the maximum expected grade to be traversed by the system.

3. Grades in Emplacement Drifts. As assumed previously, the "Repository Subsurface Layout Configuration Analysis"* identifies the grades/slope of all future emplacement drifts at +/-0.5 percent. Therefore, rounding this grade to +/-1.0 percent provides a conservative margin for the maximum expected grade to be traveled by the system within emplacement drifts.

Conclusion

Grades for the ramps and mains will not exceed +/-2.7 percent. Grades in the emplacement drifts will not exceed +/-1.0 percent.

However, in the event that the grades/slopes provided in the above Criteria Analysis require a change or increase in excess of the present maximum grades/slopes, this change would not invalidate the present concept for the system. But, it may require additional and/or larger transport locomotives to move the transporter through the ramps and drifts, and it may require larger drive units for the emplacement gantry in the emplacement drifts.

The use of unqualified input [marked *] in this analysis was necessary to establish the bounding characteristics for the design criteria. The inclusion of this input does not disqualify the results of the analysis due to the conservative margin used in establishing the bounding design criteria. Additionally, the bounding design criteria do not affect nuclear safety.

1.2.4.5 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the interface between the Subsurface Emplacement Transportation System and this system. Recovery and retrieval of WPs are expected to use the existing rail system to the extent practical. Where it is impractical, such as a damaged section of track that is unusable after an abnormal event, alternate means will be used to perform retrieval and recovery, as specified in a different criterion.

II. Criterion Performance Parameter Basis

The rail gage for the surface facilities, ramp, main drift, and turnout track is taken from "Preliminary Waste Package Transport and Emplacement Equipment Design," Section 4.3.22.

The emplacement drift rail centerline spacing is a tentative value assumed in this document based on the revised emplacement method (palletized emplacement vs. pedestal emplacement) and addition of drip shields to the Emplacement Drift System.

The rail gage is preferred as the interface for the surface facilities, ramp, main drift, and turnout track because the gage selected is a standard gage that allows the use of standardized rail equipment in the design of the system. The rail center-to-center spacing is preferred as the rail interface for the emplacement drift since the gage necessary for gantry emplacement of the WPs and drip shield is non-standard, and center to center spacing allows flexibility for the designer of the Subsurface Emplacement Transportation System to accommodate the non-standard gage without unnecessarily constraining the other system's design.

1.2.4.6 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the interface between the Subsurface Emplacement Transportation System, the Subsurface Facility System, and this system. The minimum radius of curvature that the track makes will limit the design of the equipment that rides on top of the tracks.

II. Criterion Performance Parameter Basis

The values of minimum radius of curvature are obtained from the "Repository Subsurface Layout Configuration Analysis," Section 4.3.23. Inspection of Attachment I, Figure 8 of the "Repository Surface Design Site Layout Analysis" indicates that the smallest radius of curvature on the surface is the same as that for emplacement drift turnouts.

1.2.4.7 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure the system is able to negotiate the change in elevation between the bottom of the turnout and the bottom of the emplacement drift, which is located at the emplacement drift dock.

II. Criterion Performance Parameter Basis

The difference in elevation is obtained from "Preliminary Waste Package Transport and Emplacement Design," Figure 7.9.2, and is the result of the need to excavate a step in the launching chamber to allow tunnel boring machine excavation of the emplacement drift.

1.2.4.8 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the distance over which the system will need to travel within an emplacement drift to perform emplacement or retrieval of WPs.

II. Criterion Performance Parameter Basis

Type I Analysis: Emplacement Travel Distance

Purpose

The purpose of this analysis is to identify the maximum distance the system must transport WPs within the emplacement drifts during emplacement operations.

Assumption

The maximum distance of the rail system, when measured from the drift entrance to the end of the emplacement drift, is approximately 592 m.

Rationale: The length for each emplacement drift was documented in "Repository Subsurface Layout Configuration Analysis,"* Attachment I, Table I-2. This length varies for each drift and the respective drift number. The actual length of the last usable emplacement drift (drift #120), when measured from the drift entrance to its end station, is approximately 501 m, and the usable length of the longest emplacement drift (drift #91) is 592 m. Note that this is near the midpoint of the physical emplacement drift, and represents only the distance over which the system will be able to travel, since there is a break in the Subsurface Emplacement Transportation System near the midpoint of the drift.

Criteria Analysis

The longest distance for WP emplacement in an emplacement drift is approximately 592 m (Assumption above). However, to allow for potential modifications to the present layout, a maximum distance of 700 m is selected to provide a conservative margin.

Conclusion

The system is required to transport WPs within an emplacement drift having a maximum drift length of 700 m.

However, in the event that the dimensions provided in this analysis change or increase beyond the present maximum distance, this change would not invalidate the present concept of the system for transport of WPs.

The use of unqualified input [marked *] in this analysis was necessary to establish the bounding characteristics for the design criteria. The inclusion of this input does not disqualify the results of the analysis due to the conservative margin used in establishing the bounding design criteria. Additionally, the bounding design criteria do not affect nuclear safety.

Note: Frank J. Bierich and Donald F. Smith assisted with the preparation of the preceding Criterion Basis Statement Analysis.

1.2.4.9 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the distance over which the system will need to travel within a tunnel containing two emplacement drifts to perform restoration of the system or recovery of WPs.

This criterion supports the capability to recover all WPs in an entire emplacement tunnel containing two emplacement drifts from one main drift entrance (either the east or west main) as described in the "Retrievability Strategy Report," Section 8.2.1.1. However, this capability does not preclude restoration and recovery from being conducted within a single emplacement drift if it is operationally more convenient.

II. Criterion Performance Parameter Basis

The basis for the emplacement drift maximum lengths is given in the previous criterion.

1.2.4.10 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the physical envelope interface between the system and the Ground Control System, the Emplacement Drift System, and the other equipment located in the subsurface.

II. Criterion Performance Parameter Basis

Preliminary data supporting the physical envelope values outside of emplacement drifts are noted below (reference only).

Main Drifts and Ramps-- Height:
3.58 m (Gantry height) (from "Repository Design Emplacement Gantry Plan & Elevations")
+ 1.22 m (Gantry Carrier height) (from "Repository Design Gantry Carrier Plan and Elevations")
+ 0.17 m (rail height) (rail height is from "Civil Engineering Handbook," Section 2, Table 4, based on the 115 lb/yd rail selection documented in "Repository Subsurface Layout Configuration Analysis," Section 4.3.31)
+ .63 m (additional clearance) (from "Repository Rail Electrification Analysis," Attachment I, Figure 8)
5.60 m = total height

Main Drifts and Ramps-- Width:
3.55 m (Gantry Carrier width) (from "Repository Design Gantry Carrier Plan and Elevations")

Drift Turnouts-- Height:

5.60 m (Gantry+Carrier+rail+clearance) (from main drifts and ramps height references above)

Drift Turnouts-- Width:
6.15 m (transporter door swing width) (from "Waste Package Transporter Plan & Elevations")

The emplacement drift physical envelope was taken from "Analysis of Clearance Envelopes for Emplacement Drift Operating Equipment and Space Envelopes for Test Coupons within the Emplacement Drift," Figure 1.

1.2.4.11 Criterion Basis Statement

I. Criterion Need Basis

This criterion identifies the electrical interface with the Subsurface Emplacement Transportation System.

II. Criterion Performance Parameter Basis

N/A

1.2.4.12 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure that the system will be able to operate within an emplacement drift where the power feed has been disrupted by an abnormal event. A disruption of the power feed at one end of the emplacement drift will not hinder access from the other end of the drift.

II. Criterion Performance Parameter Basis

N/A

1.2.4.13 Criterion Basis Statement

I. Criterion Need Basis

This criterion identifies the interface with the MGR Operations Monitoring and Control System and identifies communications required to support MGR RD 3.3.K. This criterion also identifies communication needed to comply with MGR RD 3.1.C, 3.2.C, 3.2.E, 10 CFR 63.111(a)(2), 10 CFR 63.111(b)(2), and 10 CFR 63.112(e)(8).

II. Criterion Performance Parameter Basis

N/A

1.2.4.15 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to identify the maximum surface dose rate to be expected at the WP surface.

II. Criterion Performance Parameter Basis

The surface dose rate is obtained from "Design Analysis for UCF Waste Packages," Section 6.2.3.1. The maximum results, i.e., the maximum dose rate on the external surface of a 44-BWR waste package, from the analysis rounded up to the nearest 10 rem/hr is specified for use in this system's design.

1.2.4.16 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to identify the maximum WP thermal output.

II. Criterion Performance Parameter Basis

The WP thermal output is obtained from "Monitored Geologic Repository Project Description Document," Section 5.2.13.

1.2.4.17 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure that the system is compatible with external interfacing MGR systems. This criterion supports MGR RD 3.3.A and 3.4.2.C.

II. Criterion Performance Parameter Basis

N/A

1.2.4.18 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure the system is able to pass through the emplacement drift isolation doors of the Subsurface Ventilation System.

II. Criterion Performance Parameter Basis

N/A

1.2.4.19 Criterion Basis Statement

I. Criterion Need Basis

This criterion provides for the tracking of all WPs handled by the system. This criterion supports MGR RD 3.3.K requirements to maintain nuclear inventories and support safeguards and security activities. This requirement supports the MGR RD 3.1.D requirement to implement applicable provisions of “Physical Protection of Plants and Materials” (10 CFR 73, Section 45(d)(1)(iii)). This requirement also supports MGR RD 3.1.C for the interim guidance of 10 CFR 63.78 which invokes “Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste” (10 CFR 72, Section 72(a)).

II. Criterion Performance Parameter Basis

N/A

1.2.5.1 Criterion Basis Statement

I. Criterion Need Basis

This criterion identifies the need to perform inspection and maintenance on system equipment. This criterion responds to MGR RD 3.1.C, 3.1.G, 3.3.A, and 10 CFR 63.112(e)(13).

This criterion is supported by guidance contained in the “MGR Compliance Program Guidance Package for the Waste Emplacement System,” Guidance Statements 6.6g5 and 6.7g5; and “MGR Compliance Program Guidance Package for the Waste Retrieval System,” Guidance Statements 6.6g5 and 6.7g5.

II. Criterion Performance Parameter Basis

N/A

1.2.5.2 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish the availability of the system. This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

The availability number is obtained from “Bounded Minimum Inherent Availability Requirements for the System Description Documents,” Table 7.2-1. The cited analysis was performed before the Waste Emplacement System and the Waste Retrieval System were combined; however, since the emplacement system was assigned an availability number, and the retrieval system was not, the availability of the combined system is the availability number for the emplacement system.

1.2.6.1 Criterion Basis Statement

I. Criterion Need Basis

This criterion is derived from regulatory precedence cited in MGR RD 3.1.B, which invokes “Standards for Protection Against Radiation” (10 CFR 20).

II. Criterion Performance Parameter Basis

N/A

1.2.6.2 Criterion Basis Statement

I. Criterion Need Basis

This criterion is derived from regulatory precedence cited in MGR RD 3.1.E, which invokes “Occupational Safety and Health Standards” (29 CFR 1910).

II. Criterion Performance Parameter Basis

N/A

1.2.6.3 Criterion Basis Statement

I. Criterion Need Basis

Use of “Manual of Steel Construction, Allowable Stress Design” in the design of this system is supported by “MGR Compliance Program Guidance Package for the Waste Emplacement System,” Guidance Statement 7.2g1; and “MGR Compliance Program Guidance Package for the Waste Retrieval System,” Guidance Statement 7.2g1.

This criterion supports MGR RD 3.1.G.

II. Criterion Performance Parameter Basis

N/A

1.2.6.4 Criterion Basis Statement

I. Criterion Need Basis

Use of “American National Standard Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants” (ANSI/ANS-57.2-1983) in the design of this system is supported by “MGR Compliance Program Guidance Package for the Waste Emplacement System," Guidance Statement 7.3g1; and "MGR Compliance Program Guidance Package for the Waste Retrieval System," Guidance Statement 7.3g1. This criterion supports MGR RD 3.1.G.

II. Criterion Performance Parameter Basis

N/A

1.2.6.5 Criterion Basis Statement

I. Criterion Need Basis

Use of "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)" (ANSI/ANS-57.9-1992) in the design of this system is supported by "MGR Compliance Program Guidance Package for the Waste Emplacement System," Guidance Statements 6.13g4 and 7.4g1; and "MGR Compliance Program Guidance Package for the Waste Retrieval System," Guidance Statements 6.13g4 and 7.4g1.

This criterion supports MGR RD 3.1.G.

II. Criterion Performance Parameter Basis

N/A

1.2.6.6 Criterion Basis Statement

I. Criterion Need Basis

Use of "American National Standard for Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 Kg) or More" (ANSI N14.6-1993) in the design of this system is supported by "MGR Compliance Program Guidance Package for the Waste Emplacement System," Guidance Statements 6.11g1 and 7.6g1; and "MGR Compliance Program Guidance Package for the Waste Retrieval System," Guidance Statements 6.11g1 and 7.6g1.

Section 7 of ANSI N14.6-1993 (addressing special lifting devices for critical loads) is not required by the criterion since the nature of the lifts performed by the system are not comparable to the critical lifts defined in the standard.

This criterion supports MGR RD 3.1.G.

II. Criterion Performance Parameter Basis

N/A

1.2.6.7 Criterion Basis Statement

I. Criterion Need Basis

Use of "Structural Welding Code - Steel" (ANSI/AWS D1.1:1998) in the design of this system is supported by "MGR Compliance Program Guidance Package for the Waste Emplacement System," Guidance Statement 7.5g1; and "MGR Compliance Program Guidance Package for the Waste Retrieval System," Guidance Statement 7.5g1.

This criterion supports MGR RD 3.1.G.

II. Criterion Performance Parameter Basis

N/A

1.2.6.8 Criterion Basis Statement

I. Criterion Need Basis

Use of "Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)" (ASME NOG-1-1995) in the design of this system is supported by "MGR Compliance Program Guidance Package for the Waste Emplacement System," Guidance Statement 7.11g1; and "MGR Compliance Program Guidance Package for the Waste Retrieval System," Guidance Statement 7.11g1.

This criterion supports MGR RD 3.1.G.

II. Criterion Performance Parameter Basis

N/A

1.2.6.9 Criterion Basis Statement

I. Criterion Need Basis

Use of "Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes" (CMAA-70-94) in the design of this system is supported by "MGR Compliance Program Guidance Package for the Waste Emplacement System," Guidance Statements 6.11g2 and 7.15g1; and "MGR Compliance Program Guidance Package for the Waste Retrieval System," Guidance Statements 6.11g2 and 7.15g1.

This criterion supports MGR RD 3.1.G.

II. Criterion Performance Parameter Basis

N/A

1.2.6.11 Criterion Basis Statement

I. Criterion Need Basis

This criterion responds to MGR RD 3.3.A, which recommends compliance with industry codes and standards. The “National Electrical Code” (NFPA 70) contains provisions considered necessary for safeguarding of personnel and SSCs from hazards arising from the use of electricity.

II. Criterion Performance Parameter Basis

N/A

1.2.6.12 Criterion Basis Statement

I. Criterion Need Basis

The “Monitored Geologic Repository Project Description Document” allocates controlled project assumptions to systems. This criterion identifies the need to comply with the applicable assumptions identified in the subject document. The approved assumptions will provide a consistent basis for continuing the system design.

II. Criterion Performance Parameter Basis

N/A

1.2.6.13 Criterion Basis Statement

I. Criterion Need Basis

This criterion is derived from regulatory precedence cited in MGR RD 3.1.F, which invokes “Safety and Health Regulations for Construction” (29 CFR 1926).

II. Criterion Performance Parameter Basis

N/A

APPENDIX B ARCHITECTURE AND CLASSIFICATION

The system architecture and QA classification are identified in Table 14. The QA classifications are established in "Classification of the Waste Emplacement/Retrieval System."

Table 14. System Architecture and QA Classification

System Architecture	Classification			
	QL-1	QL-2	QL-3	CQ
Emplacement, Retrieval, and Recovery Systems (Normal Conditions)				
Waste Package Transporter	X			
Gantry Carrier				X
Emplacement Gantry		X		
Recovery Systems (Abnormal Conditions)				
Main Drift Forklift			X	
Forks				
Manipulating Arm				
Emplacement Drift Forklift			X	
Forks				
Manipulating Arm				
Ejector Bucket				
Multi-Purpose Hauler			X	
Bottom Lift Transporter			X	
Bottom Lift Transporter Carrier	X			
Multi-Purpose Vehicle			X	
Impact Hammer				
Demolition Shears				
Bucket				
Load-Haul-Dump Loader			X	
Covered Shuttlecars				X
Scaling Machine				X
Extendable Conveyor				X
Ball Screw Jack				X
Temporary Dock				X
Modified WP Transporter	X			
Temporary Shielding				
Temporary Ventilation Control and Filtration System				
Temporary Ground Support Subsystems				
Decontamination Equipment		X		
Restoration Systems (Abnormal Conditions)				
Re-Railer				X
Emplacement Drift Restoration Locomotive			X	
Emplacement Drift Gantry Carrier				X
Cleanup and Construction Vehicles				X
General Support Systems				
Locomotives	X			
Railcars				X
Control and Tracking System	X			

APPENDIX C ACRONYMS, SYMBOLS, AND UNITS

C.1 ACRONYMS

This section provides a listing of acronyms used in this SDD.

ALARA	As Low as is Reasonably Achievable
CPA	Controlled Project Assumptions
DC	direct current
ESF	Exploratory Studies Facility
F	Function
I/O	Input/Output
MGR	Monitored Geologic Repository
MGR RD	Monitored Geologic Repository Requirements Document
N/A	not applicable
PLC	Programmable Logic Controller
QA	Quality Assurance
SSCs	structures, systems, and components
TBD	to be determined
TBV	to be verified
WHB	Waste Handling Building
WP	waste package

C.2 SYMBOLS AND UNITS

This section provides a listing of symbols and units used in this SDD.

%	percent
ºF	degrees Fahrenheit
cm	centimeter
ft	foot
g	acceleration of gravity
hp	horespower
hr	hour
in.	inch
kg	kilogram
km	kilometer
lb	pound
m	meter
min	minute
mm	millimeter
mph	miles per hour
mrem	milli- roentgen equivalent man
rad	radiation absorbed dose
rem	roentgen equivalent man
sec	second
yd	yard
yr	year

APPENDIX D FUTURE REVISION RECOMMENDATIONS AND ISSUES

Issue 1 Consider the applicability and/or removal of Criterion 1.2.1.19 in the next revision of this document. This criterion currently requires that the Waste Emplacement/Retrieval System limit waste package temperature during retrieval, recovery, or restoration. Is it realistic to expect this system (the waste transporter in particular) to have the capability to maintain waste package temperature?

Issue 2 Consider the applicability and/or removal of Criterion 1.2.1.26 in the next revision of this document. This criterion currently requires that the Waste Emplacement/Retrieval System limit the heat flux on the surface of the Naval SNF canister. Is it realistic to expect this system (the waste transporter in particular) to have the capability to maintain Naval SNF canister heat flux?

Issue 3 Consider the applicability and/or removal of Criterion 1.2.6.12 in the next revision of this document. Replacement of direct tracing of requirements to specific sections of the MGR RD with direct tracing to specific sections of the MGR PDD is under consideration for the next revision of this document.

APPENDIX E MONITORING AND CONTROL SYSTEM INPUT/OUTPUT LISTS

E.1 Transporter

This railcar transports WPs in a shielded enclosure. Transporter operation and functions will be controlled from either the operator located on the primary locomotive, or from operators located in the remote control room. In either case, the control signals will be processed by the PLC-based control system located on the primary transportation locomotive, and then communicated to a PLC-based control system located on the transporter. The PLC on the primary locomotive will monitor and check system performance parameters ("Instrumentation and Controls for Waste Emplacement," Section 6.8).

A preliminary order-of-magnitude input/output (I/O) list summarizing control and monitoring requirements is found in Table 15 ("Instrumentation and Controls for Waste Emplacement," Table 8).

Table 15. Preliminary Transporter Control System I/O List

On-Board Systems	I/O Quantity
I. Transporter Braking System	
Primary Brake Engine	2
Primary Brake Status	2
Secondary Brake Engage	2
Secondary Brake Status	2
Brake Temperature Sensors	8
II. Actuator Systems: Loading Mechanism	
Actuator Motor Control Unit	4
Actuator Motor Control: Power On/Off	2
Actuator Motor Control: Status	2
Actuator Motor Control: Direction	2
Actuator Motor Control: Position	2
Actuator Motor Control: Speed	2
Limit Switches	8
Power, Voltage, Current	6
Motor Temperature Sensors	8
III. Transporter Vision System	
Video Switch Controller (2 Cameras)	3
Video Controls (Power, Zoom, Balance)	4
Pan/Tilt Unit Controller (1 Unit)	6
Lighting System	4
IV. Transporter Thermal Monitoring and Control System	
Electronic Enclosure Thermal Monitoring	8
Electronic Enclosure Cooling	4
Motor Housing Thermal Monitoring	4
Motor Housing Cooling	4
Environmental Temperature Monitoring	4
V. Radiological Monitoring System	
Equipment Exposure Dosimetry	8
Environmental Monitoring	8
VI. Locomotive Interface with Transporter	1
Total	110

E.2 Locomotives

The locomotives will serve as multi-purpose prime movers of equipment and personnel. They will be used not only for emplacement, but also for retrieval, performance confirmation, and other activities. Their principal function, however, is to transport WPs between the WHB and an emplacement drift.

The locomotives will be instrumented to monitor internal and external parameters important to safe vehicle control and operation. These include monitoring temperatures of key on-board systems, monitoring external temperatures and radiation levels, and monitoring current draw and voltage levels. This data will be fed to an on-board controller and also relayed to the remote control room ("Instrumentation and Controls for Waste Emplacement," Section 6.7.1).

The locomotives will be equipped for both manual and remote control operation and for operation as either the primary or secondary locomotive when used in the tandem mode. During manual operation, the locomotives will also be continuously monitored from the remote control room to ensure safe and proper operation. When operated in the remote control mode, all locomotive functions will be initiated and monitored from the control room. The remote operators will receive extensive data on all performance parameters including visual feedback of the area around the locomotive ("Instrumentation and Controls for Waste Emplacement," Section 6.7.1).

Electrical and pneumatic interfaces will be required between the primary and secondary locomotives. These interfaces will be facilitated by quick-disconnect connections located at the front and rear of each locomotive. When the locomotives are in the tandem-control configuration, the electrical and pneumatic connections will be provided by feed-through connections on the transporter ("Instrumentation and Controls for Waste Emplacement," Section 6.7.2).

A preliminary locomotive control system I/O list is provided in Table 16 ("Instrumentation and Controls for Waste Emplacement," Table 7).

Table 16. Preliminary Locomotive Control System I/O List

On-Board Systems	I/O Quantity
I. Locomotive Power System	
Power Pickup Status Monitoring (Voltage, Power)	10
Power Distribution System (Voltage and Current Levels)	12
II. Locomotive Communication System	
Communication System Status	8
Communication System Interfaces	4
III. Locomotive Drive System	
Drive Motor Control Unit (one fore and one aft)	4
Drive Motor Control: Power On/Off	2
Drive Motor Control: Status	2
Drive Motor Control: Direction	2
Drive Motor Control: Fine Positioning	2
Drive Motor Control: Speed	2
Drive Motor Control: Acceleration	2

Table 16. Preliminary Locomotive Control System I/O List (Continued)

On-Board Systems	I/O Quantity
Locomotive Coarse Positioning System	6
Power, Voltage, Current	12
Primary Brake Engage	2
Primary Brake Status	2
Secondary Brake Engage	2
Secondary Brake Status	2
Brake Temperature Sensors	8
IV. Tandem Locomotive Control Interface	1
V. Locomotive Interface with Transporter	1
VI. Locomotive Interface with Gantry Carrier	1
VII. Vision System	
Video Switch Controller (4 Cameras)	6
Video Controls (Power, Zoom, Balance)	8
Pan/Tilt Unit Controller (2 units)	11
Lighting System	8
VIII. Thermal Monitoring and Control System	
Electronic Enclosure Thermal Monitoring	8
Electronic Enclosure Cooling	4
Motor Housings Thermal Monitoring	4
Motor Housing Cooling	4
Environmental Temperature Monitoring	4
IX. Radiological Monitoring System	
Equipment Exposure Dosimetry	8
Environmental Monitoring	8
X. Safety and Auxiliary Systems	
Backup Power System	6
Fire Suppression System	4
Total	170

E.3 Emplacement Gantry

The gantry will be designed to operate in the relatively harsh thermal and radiation environment located inside the emplacement drifts. Due to these conditions, the gantry will be remotely controlled by operators located in the remote control room.

Control and monitoring is required for the following systems: vehicle locomotion and braking, WP hoisting mechanisms, vision systems, thermal monitoring and control, radiological monitoring, on-board safety system (fire detection and control), and redundant power system. Order-of-magnitude I/O requirements for all of the on-board gantry systems are summarized in Table 17 (“Instrumentation and Controls for Waste Emplacement,” Table 5).

Table 17. Preliminary Emplacement Gantry Control System Input/Output List

On-Board Systems	I/O Quantity
I. Gantry Power System	
Power Pickup Status Monitoring (Voltage, Power)	10
Power Distribution System (Voltage and Current Levels)	12
II. Gantry Communication System	
Communication System Status	8
Communication System Interfaces	4
III. Gantry Drive System	
Drive Motor Control Unit	4
Drive Motor Control: Power On/Off	2
Drive Motor Control: Status	2
Drive Motor Control: Direction	2
Drive Motor Control: Fine Positioning	2
Drive Motor Control: Speed	2
Drive Motor Control: Acceleration	2
Gantry Coarse Positioning System	6
Power, Voltage, Current	12
Primary Brake Engage	2
Primary Brake Status	2
Secondary Brake Engage	2
Secondary Brake Status	2
Temperature	8
IV. Actuation Systems: Lifting Head and Hoist	
Actuator Motor Control Unit	4
Actuator Motor Control: Power On/Off	2
Actuator Motor Control: Status	2
Actuator Motor Control: Direction	2
Actuator Motor Control: Position	2
Actuator Motor Control: Speed	2
Limit Switches	16
Load Sensors	8
Power, Voltage, Current	12
Temperature	8
V. Gantry Vision System	
Video Switch Controller (8 Cameras)	10
Video Controls (Power, Zoom, Balance)	8
Pan/Tilt Unit Controller (4 units)	12
Lighting System	8
VI. Gantry Thermal Monitoring and Control System	
Electronic Enclosure Thermal Monitoring	8
Electronic Enclosure Cooling	4
Motor Housings Thermal Monitoring	4
Motor Housing Cooling	4
Environmental Temperature Monitoring	4
VII. Radiological Monitoring System	
Equipment Exposure Dosimetry	8
Environmental Monitoring	8
VIII. Safety and Auxiliary Systems	
Backup Power System	6
Fire Suppression System	4
Total	230

E.4 Emplacement Gantry Carrier

The gantry carrier is basically a special railcar that will be used to shuttle the emplacement gantry between emplacement drifts and the surface storage and maintenance facility. The carrier will be moved by the transport locomotives and will not be equipped with its own control system. Rather, all control and monitoring functions will interface directly with the locomotive I/O system through the use of quick-disconnect, feed-through connectors.

A preliminary order-of-magnitude I/O list for the gantry carrier is found in Table 18 ("Instrumentation and Controls for Waste Emplacement," Table 6).

Table 18. Preliminary Emplacement Gantry Carrier Control System Input/Output List

Control System Interface	**I/O Quantity**
I. Carrier Braking System	
Primary Brake Engage	2
Primary Brake Status	2
Secondary Brake Engage	2
Secondary Brake Status	2
Temperature	8
II. Gantry Power System	
Conductor Bar Power: On/Off	4
Conductor Bar Power Level	6
III. Transport Locomotive Interface	2
IV. Emplacement Gantry Interface	2
Total	30

APPENDIX F TRANSPORTER AND LOCOMOTIVE SAFETY EVALUATIONS

F.1 Transporter Safety Features

The primary brake system consists of an automatic fail-safe, tread-brake system. In this system, a spring-acting cylinder provides the stopping force. Powerful and appropriately sized compression springs within the cylinder, force brake shoes against the wheels, slowing or stopping the transporter. The springs are collapsed (and the spring-force released) by the application of air pressure supplied in a train line from the locomotive compressor and reservoir. If air pressure on the springs decreases, brake shoe force on the wheel is proportionally increased ("Subsurface Transporter Safety Systems Analysis," Section 6.1.1.1).

In the redundant brake system, a caliper is mounted on each axle of the transporter trucks. The calipers are hydraulically applied and spring released, which is not a fail-safe configuration. Pressure is applied to the brake calipers through a hydraulic line from the locomotive hydraulic system ("Subsurface Transporter Safety Systems Analysis," Section 6.1.1.1).

F.2 Locomotive Safety Systems

The locomotive braking system is described in Subsurface Transporter Safety System Analysis," Section 6.1.2.1, and consists of four brake systems: tread, disk, parking, and dynamic brakes. The tread and disk brakes can each stop the train independently. The parking brake holds the train in position once stopped. The dynamic braking systems regulate the train speed as it descends the North Ramp, but would not be used for a complete stop.

The locomotive tread brakes are automatic, fail-safe air brakes, similar to the transporter tread brakes. Like the transporter brakes, the stopping force of the locomotive tread brakes is provided by powerful compression springs. Air pressure is used to collapse the springs, thereby releasing the brake shoes from the locomotive wheels.

The disk brakes are the backup, redundant brake system installed within the transmissions of the locomotive. The disk brake calipers are hydraulically applied and spring released, which is not a fail-safe configuration.

The locomotive parking brake is a spring-applied, manual-release disk brake. The brake consists of an independent caliper mounted to operate on the same disk as the redundant disk brake system.

Dynamic braking uses the locomotive direct-current drive motors to control train speeds on steep grades. The locomotive wheels are allowed to transfer mechanical power opposite the moving directions by back-driving the transmissions and drive motors. Extended-range dynamic braking may be included on the locomotive, allowing it to be used at speeds as low as 4.8 km/hr (3 mph).

F.3 Safety Evaluation Results

The analysis showed that the maximum transporter operating speed of 8 km/hr (5 mph) is 2.82 times slower than the speed developed in a 2-m (6.6-ft) design basis WP drop ("Subsurface Transporter Safety Systems Analysis," Section 6.6).

From the maximum operating speed, the transporter will take 13.6 m (44.6 ft) to stop at a 13 percent brake ratio. From the same speed, a full emergency brake application (60 percent brake ratio) will stop the transporter in 1.58 m (5.18 ft) ("Subsurface Transporter Safety Systems Analysis," Section 6.3.3).

Calculations of a hypothetical runaway scenario, with the runaway train reaching a velocity of 31 m/sec (70 mph), concluded that the equivalent stopping distances are 2,428 m (7,967 ft) at a 13 percent brake ratio, and 308 m (1,010 ft) with the emergency brake application (60 percent brake ratio) ("Subsurface Transporter Safety Systems Analysis," Table 5). Calculations of various runaway scenarios also show that the runaway velocity is above the tip-over speed. Therefore, it is possible for the loaded WP transporter to tip over during the defined runaway scenario ("Subsurface Transporter Safety Systems Analysis," Section 6.4.3).

Impact limiters are devices attached to the WP transporter that would help absorb impact energy in the event of a collision. For a tip-over situation in a worst-case runaway condition, the transporter will not completely rotate onto its side within the North Ramp curve, which is the calculated tip-over location. The top of the transporter, above the deck level, will impact the wall; therefore, impact limiters installed at the deck level and on the ends will provide negligible impact protection ("Subsurface Transporter Safety Systems Analysis," Section 6.5).

An analysis for derailment showed that a wheel-climb derailment was only possible with severely worn wheels under full runaway conditions ("Subsurface Transporter Safety Systems Analysis," Section 7). This condition will be prevented by inspection and replacement of the wheels before they become severely worn. However, other types of derailment would still be possible. Following derailment, the transporter would hit the wall at the North Ramp curve on a course almost parallel to the wall. For this lateral impact, the impact protection from an impact limiter installed on the front of the transporter deck would be negligible in the case of derailment ("Subsurface Transporter Safety Systems Analysis," Section 6.5).

F.4 Mitigation Measures

The analysis suggests that considerable additional impact protection for a runaway transporter could be provided by incorporating an energy-absorbing layer on the inside of the radiological shield of the transporter ("Subsurface Transporter Safety Systems Analysis," Section 6.5), although it would increase the overall size of the shielding. Also, additional controls were identified to mitigate an uncontrolled descent. These include magnetic track brakes and car retarders. Magnetic track brakes are capable of providing railcar deceleration rates on the order of 2.46 to 3.58 m/sec^2 (5.5 to 8.0 mph/sec). Car retarders include wheel clamp and hydraulic piston-type retarders. The former produce friction by clamping on both sides of each rail wheel, while the latter are passive energy absorption systems similar in function to a shock absorber.

For the safety classification of SSCs, an event is considered to be credible or probable if its estimated frequency of occurrence is 1×10^{-6}/yr or greater. The safety analysis concluded that a runaway transporter event could not be screened out as a credible event (design basis event). It was also concluded that it is feasible to reduce the event frequency to an acceptable level by either enhancing the design on the onboard brake, control, and communications systems, or by installing speed retarder units on the rails of the North Ramp ("Subsurface Transporter Safety Systems Analysis," Section 7.1).

APPENDIX G REFERENCES

This section provides a listing of references used in this SDD. References list the Accession number or Technical Information Catalog number at the end of the reference, where applicable.

"American National Standard Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants." American Nuclear Society. ANSI/ANS-57.2-1983. 1983. La Grange Park, Illinois: American Nuclear Society. TIC: 8518.

"American National Standard for Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 Kg) or More." American National Standards Institute. ANSI N14.6-1993. 1993. New York, New York: American National Standards Institute. TIC: 236261.

"Analysis of Clearance Envelopes for Emplacement Drift Operating Equipment and Space Envelopes for Test Coupons within the Emplacement Drift." CRWMS M&O. BCA000000-01717-5705-00007, Rev. 00. July 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991018.0232.

"Bottom/Side Lift Gantry Conceptual Design." CRWMS M&O. ANL-WES-ME-000003, Rev. 01. April 11, 2000. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000420.0399.

"Bounded Minimum Inherent Availability Requirements for the System Description Documents." CRWMS M&O. B00000000-01717-0200-00147, Rev. 00. March 13,1998. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980416.0791.

"Civil Engineering Handbook." Urquhart, Leonard C. (editor). Fourth Edition. 1959. New York, New York: McGraw-Hill Book Company, Inc. TIC: 240754.

"Classification of the Waste Emplacement/Retrieval System." CRWMS M&O. RSO-RSO-99339.T. November 19, 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991122.0206.

"Decision Package Executive Summary, Strategy to Mitigate Preclosure Offsite Exposure." CRWMS M&O. YD-199800021. July 21, 1998. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980916.0359.

"Design Analysis for the Ex-Container Components." CRWMS M&O. ANL-XCS-ME-000001, Rev. 00. 2000. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000525.0374.

"Design Analysis for UCF Waste Packages." CRWMS M&O. ANL-UDC-MD-000001, Rev. 00. May 18, 2000. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0336.

"Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)." American Nuclear Society. ANSI/ANS-57.9-1992. 1992. La Grange Park, Illinois: American Nuclear Society. TIC: 3043.

"Emplacement Drift System Description Document." CRWMS M&O. SDD-EDS-SE-000001, Rev. 00. December 13, 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000121.0119.

"Engineering Design Climatology and Regional Meteorological Conditions Report." CRWMS M&O. B00000000-01717-5707-00066, Rev. 00. October 2, 1997. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980304.0028. DTN: MO9811DEDCRMCR.000.

"ESF Layout Calculation." CRWMS M&O. BABEAD000-01717-0200-00003, Rev. 04. April 11, 1996. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19960930.0095.

"Exploratory Studies Facility TS North Ramp General Arrangement Plan & Profile." CRWMS M&O. BABEAD000-01717-2100-40104, Rev. 02. September 22, 1995. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19960422.0065.

"Federal Mine Safety and Health Act of 1977." U.S. Congress. 30 U.S.C. 801, et seq. January 5, 1999. Readily Available

"Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low as is Reasonably Achievable." U.S. Nuclear Regulatory Commission. Regulatory Guide 8.8, Rev. 3. June 1978. Washington, D.C.: U.S. Nuclear Regulatory Commission, Office of Standards Development. Readily Available.

"Instrumentation and Controls for Waste Emplacement." CRWMS M&O. ANL-WES-CS-000001, Rev. 00 ICN 01. July 12, 2000. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000825.0004

"Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste." U.S. Nuclear Regulatory Commission. 10 CFR 72. January 1, 1999. Washington, D.C.: U.S. Government Printing Office. Readily Available

"Manual of Standards and Recommended Practices Section G -- Wheels and Axles." Association of American Railroads, Operations and Maintenance Department, Mechanical Division. Issue of 1998. May 1, 1998. Washington, D.C.: Association of American Railroads. TIC: 243748.

"Manual of Steel Construction, Allowable Stress Design." American Institute of Steel Construction, Inc. Ninth Edition. January 1997. Chicago, Illinois: American Institute of Steel Construction, Inc. TIC: 232994.

"Memorandum of Agreement for Acceptance of Naval Spent Nuclear Fuel." Bowman, F.L. and Itkin, I. Rev. 01. April 11, 2000. ACC: HQP.20000628.0006.

"MGR Compliance Program Guidance Package for the Waste Emplacement System." CRWMS M&O. BCA000000-01717-5600-00003, Rev. 01. October 26, 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991118.0189.

"MGR Compliance Program Guidance Package for the Waste Retrieval System." CRWMS M&O. BCA000000-01717-5600-00008, Rev. 01. October 26, 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991118.0190.

"MGR Design Basis Extreme Wind/Tornado Analysis." CRWMS M&O. ANL-MGR-SE-000001, Rev. 00. October 28, 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991215.0461.

"Mobile Waste Handling Support Equipment." CRWMS M&O. BCAF00000-01717-0200-00006, Rev. 00. July 9, 1998. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980819.0397.

"Monitored Geologic Repository Project Description Document." Bechtel SAIC Company. TDR-MGR-SE-000004, Rev. 02 ICN 02. June 2001. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010628.0224.

"Monitored Geologic Repository Requirements Document." U.S. Department of Energy. YMP/CM-0025, Rev. 3, DCN 02. May 2000. Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Yucca Mountain Site Characterization Office. ACC: MOL.20000720.0540.

"Monitored Geologic Repository Site Layout System Description Document." CRWMS M&O. BCB000000-01717-1705-00007, Rev. 00. February 15, 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990512.0159.

"National Electrical Code." National Fire Protection Association. NFPA 70, 1999 Edition. August 6, 1998. Quincy, Massachusetts: National Fire Protection Association. TIC: 240528.

"Nuclear Waste Policy Act of 1982." U.S. Congress. 42 U.S.C. 10101, et seq. January 26, 1998. Readily Available.

"Occupational Safety and Health Standards." Occupational Safety and Health Administration, Department of Labor. 29 CFR 1910. July 1, 1999. Washington, D.C.: U.S. Government Printing Office. Readily Available.

"Performance Confirmation Emplacement Drift Monitoring System Description Document." CRWMS M&O. BCA000000-01717-1705-00020, Rev. 00. July 24, 1998. MOL.19981208.0234.

"Performance Confirmation Plan." CRWMS M&O. TDR-PCS-SE-000001, Rev. 01 ICN 01. May 24, 2000. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000601.0196.

"Physical Protection of Plants and Materials." U.S. Nuclear Regulatory Commission. 10 CFR 73. January 1, 1999. Washington, D.C.: U.S. Government Printing Office. Readily Available.

"Preliminary Selection of MGR Design Basis Events." CRWMS M&O. ANL-WHS-SE-000003, Rev. 00. September 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990720.0406.

"Preliminary Waste Package Transport and Emplacement Equipment Design." CRWMS M&O. BCA000000-01717-0200-00012, Rev. 00. September 16, 1997. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980511.0131.

"Quality Assurance Requirements and Description." U.S. Department of Energy. DOE/RW-0333P, Rev. 10. April 2000. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000427.0422.

"Radiological Control Manual." TMSS/DOE/RP/001, Rev. 1. April 1994. Washington, D.C.: U.S. Department of Energy. ACC: MOL.19950130.0075.

"Repository Design Emplacement Gantry Plan & Elevations." CRWMS M&O. BCAF00000-01717-2700-85007, Rev. 00. September 22, 1997. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980120.0015.

"Repository Design Gantry Carrier Plan and Elevations." CRWMS M&O. BCAF00000-01717-2700-85004, Rev. 00. September 22, 1997. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980119.0473.

"Repository Rail Electrification Analysis." CRWMS M&O. BCAC00000-01717-0200-00002, Rev. 00. September 12, 1997. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980122.0462.

"Repository Subsurface Layout Configuration Analysis." CRWMS M&O. BCA000000-01717-0200-00008, Rev. 00. July 17, 1997. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971201.0879.

"Repository Surface Design Site Layout Analysis." CRWMS M&O. BCB000000-01717-0200-00007, Rev. 02. February 27, 1998. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980410.0136.

"Retrievability Strategy Report." CRWMS M&O. B00000000-01717-5705-00061, Rev. 01 DCN 1. August 1998. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990201.0011.

"Retrieval Equipment and Strategy." CRWMS M&O. BCAF00000-01717-0200-00008, Rev. 00. December 2, 1998. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990414.0212.

"Retrieval Equipment and Strategy for WP on Pallet." CRWMS M&O. 00319.T. July 19, 2000. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000719.0345.

"Revised Interim Guidance Pending Issuance of New U.S. Nuclear Regulatory Commission (NRC) Regulations (Revision 01, July 22, 1999), for Yucca Mountain, Nevada." U.S. Department of Energy. OL&RC:SB-1714. September 3, 1999. North Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Yucca Mountain Site Characterization Office. ACC: MOL.19990910.0079.

"Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)." American Society of Mechanical Engineers. ASME NOG-1-1995. 1995. New York, New York: American Society of Mechanical Engineers. TIC: 238309.

"Safety and Health Regulations for Construction." Occupational Safety and Health Administration, Department of Labor. 29 CFR 1926. July 1, 1999. Washington, D.C.: U.S. Government Printing Office. Readily Available.

"Safety Criteria for SDD SS-17, Waste Emplacement System." CRWMS M&O. LV.SA.DDO.03/98-022. March 27, 1998. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980415.0491.

"Seismic Design Basis Inputs for a High-Level Waste Repository at Yucca Mountain, Nevada." CRWMS M&O. B00000000-01727-5700-00018, Rev. 0. February 23, 1998. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980806.0711.

"Site Characterization Plan Thermal Goals Reevaluation." CRWMS M&O. B00000000-01717-5705-00005, Rev. 00. September 8, 1993. Las Vegas, Nevada: CRWMS M&O. ACC: NNA.19931208.0034.

"Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada." U.S. Department of Energy, Office of Civilian Radioactive Waste Management. DOE/RW-0199. December 1988. Oak Ridge, Tennessee: U.S. Department of Energy, Office of Scientific and Technical Information. ACC: HQO.19881201.0002.

"Site Recommendation Subsurface Layout." CRWMS M&O. ANL-SFS-MG-000001, Rev. 00. 2000. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000908.0276.

"Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes." Crane Manufacturers Association of America, Inc. CMAA-70-94. 1994. Charlotte, North Carolina: Crane Manufacturers Association of America. TIC: 240767.

"Standards for Protection Against Radiation." U.S. Nuclear Regulatory Commission. 10 CFR 20. January 1, 1999. Washington, D.C.: U.S. Government Printing Office. Readily Available.

"Strategy to Mitigate Preclosure Offsite Exposure." CRWMS M&O. LV.SEI.CRH.7/98-024. July 21, 1998. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980916.0357.

"Strategy to Mitigate Preclosure Offsite Exposure." CRWMS M&O. RSO-RSO-99352.T. December 3, 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991206.0070.

"Structural Welding Code - Steel." American Welding Society. ANSI/AWS D1.1:1998, 16th Edition. 1998. Miami, Florida: American Welding Society. TIC: 236843.

"Subsurface Repository Slopes." CRWMS M&O. BCAA00000-01717-0200-00007, Rev. 00. June 26, 1997. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971125.0578.

"Subsurface Transporter Safety Systems Analysis." CRWMS M&O. ANL-WER-ME-000001, Rev. 00. February 18, 2000. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000225.0052.

"Subsurface Ventilation System Description Document." CRWMS M&O. SDD-SVS-SE-000001, Rev. 00. January 7, 2000. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000217.0221.

"Technical Reports." U.S. Department of Energy Office of Civilian Radioactive Waste Management. AP-3.11Q, Rev. 1, ICN 1. June 2, 2000. Las Vegas, Nevada: U.S. Department of Energy Office of Civilian Radioactive Waste Management. ACC: MOL.20000714.0549.

"Technical Work Plan For Subsurface Design Section FY 01 Work Activities." CRWMS M&O. TWP-MGR-MG-000001. Rev. 01. January 25, 2001. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010207.0158.

"Thermal Loading Study for FY 1996." CRWMS M&O. B00000000-01717-5705-00044, Rev. 01. November 8, 1996. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19961217.0121.

"Thermal, Shielding, and Structural Information on the Naval Spent Nuclear Fuel (SNF) Canister." Naples, E.M. August 6, 1999. Arlington, Virginia: Department of Defense, Department of the Navy, Naval Sea Systems Command. ACC: MOL.19991001.0133.

"Underground Temperature Data." CRWMS M&O. RSO-SSR-99354-T. December 9, 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991209.0107.

"Underground Temperature Data Aug 95 to Jan 97 for STA 1+70, 7+54 & 28+26 - IOC.013." CRWMS M&O. LV.RD.NK.04/97.013. April 16, 1997. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19970815.0127.

"Waste Acceptance System Requirements Document." Office of Acceptance, Transportation, and Integration. DOE/RW-0351 (E00000000-00811-1708-00001), Rev. 03. April 1999. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: HQO.19990226.0001.

"Waste Handling Building Ventilation System Description Document." CRWMS M&O. SDD-HBV-SE-000001, Rev. 01. April 21, 2000. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000602.0059.

"Waste Package Design Basis Events." CRWMS M&O. BBA000000-01717-0200-00037, Rev. 00. April 18, 1997. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971006.0075.

"Waste Package Retrieval Equipment." CRWMS M&O. BCAF00000-01717-0200-00004, Rev. 00. August 14, 1997. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971210.0062.

"Waste Package Transport and Transfer Alternatives." CRWMS M&O. ANL-WES-ME-000001, Rev. 00. March 16, 2000. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000317.0261.

"Waste Package Transporter Plan & Elevations." CRWMS M&O. BCAF00000-01717-2700-85001, Rev. 00. September 22, 1997. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980119.0385.