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QA: N/A

AUG 22 2001

OVERNIGHT MAIL

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TRANSMITTAL OF *RETRIEVAL EQUIPMENT AND STRATEGY FOR WASTE PACKAGE (WP) ON PALLET*, ANL-WES-ME-000006, REVISION 00

In a request from the U.S. Nuclear Regulatory Commission (NRC) on-site representative, the NRC and the Center for Nuclear Waste Regulatory Analysis staff asked for a copy of *Retrieval Equipment and Strategy*, BCAF00000-01717-0200-00008, Revision 00 and *Retrieval Equipment and Strategy for WP on Pallet,* ANL-WRS-ME-000002, Revision 00. These two documents have been superseded by *Retrieval Equipment and Strategy for WP on Pallet,* ANL-WES-ME-000006, Revision 00, a copy of which is enclosed for your information.

Please direct any questions concerning this letter and its enclosure to Timothy C. Gunter at (702) 794-1343.

for Stephan Brocoum
Assistant Manager, Office of
Licensing and Regulatory Compliance

OL&RC:TCG-1576

Enclosure:
Retrieval Equipment and Strategy for WP on Pallet, ANL-WES-ME-000006, Revision 00

WM-11

NMSS07

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ANALYSIS/MODEL COVER SHEET
Complete Only Applicable Items

1. QA: QA

Page: 1 of: 83

2. ☒ Analysis — Check all that apply		3. ☐ Model — Check all that apply	
Type of Analysis	☒ Engineering ☐ Performance Assessment ☐ Scientific	Type of Model	☐ Conceptual Model ☐ Abstraction Model ☐ Mathematical Model ☐ System Model ☐ Process Model
Intended Use of Analysis	☐ Input to Calculation ☐ Input to another Analysis or Model ☐ Input to Technical Document ☒ Input to other Technical Products	Intended Use of Model	☐ Input to Calculation ☐ Input to another Model or Analysis ☐ Input to Technical Document ☐ Input to other Technical Products
Describe use:	Input to Waste Emplacement/Retrieval System Description Document and other System Description Documents that are Direct Inputs to the Site Recommendation Consideration Report	Describe use:	

4. Title:

RETRIEVAL EQUIPMENT AND STRATEGY FOR WP ON PALLET

5. Document Identifier (including Rev. No. and Change No., if applicable):

ANL-WES-ME-000006 REV 00

6. Total Attachments: None

7. Attachment Numbers - No. of Pages in Each: N/A

	Printed Name	Signature	Date
8. Originator	T. W. Wilson For	[signature]	9/14/00
9. Checker	Bruce Stanley	Bruce T. Stanley	9/14/00
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12. Remarks:

- Section 6.3 prepared by Dr. Martin Haas and Dr. Ernesto Faillace.

ENCLOSURE

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
ANALYSIS/MODEL REVISION RECORD
Complete Only Applicable Items

2. Analysis or Model Title:
RETRIEVAL EQUIPMENT AND STRATEGY FOR WP ON PALLET

3. Document Identifier (including Rev. No. and Change No., if applicable):
ANL-WES-ME-00006 Rev. 00

4. Revision/Change No.	5. Description of Revision/Change
00	This analysis supercedes the *Retrieval Equipment and Strategy* analysis (BCAF00000-01717-0200-00008 REV 00) due to design criteria changes prompted by EDA II and SR designs. In addition, this analysis supercedes the Input Transmittal *Retrieval Equipment and Strategy for WP on Pallet* (Input Tracking No. 00319.T).

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FIGURES

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TABLES

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LIST OF ACRONYMS AND ABBREVIATIONS

ACRONYMS

ALARA	As low as is reasonably achievable
ALI	Annual limit on intake
DAC	Derived air concentration
EDA	Enhanced Design Alternative
ECL	Effluent Concentration Limit
MGR	Monitored Geologic Repository
NRC	Nuclear Regulatory Commission
SR	Site Recommendation
TBD	to be determined
TBV	to be verified
VA	Viability Assessment
WHB	Waste Handling Building
WP	waste package
WERS	Waste Emplacement/Retrieval System

ABBREVIATIONS

cm	Centimeters
dpm	Disintegrations per minute
km	Kilometers
rem	roentgen equivalent man (measure of absorbed dose)
Sv	Sieverts

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1. PURPOSE

The purpose of this analysis is to revisit the retrieval equipment and associated retrieval strategy in order to address the impacts to the original *Retrieval Equipment and Strategy* analysis (CRWMS M&O 1998a) imparted by changes to the design criteria, as described below. This analysis has been prepared with the intent of supporting applicable System Description Documents and the Site Recommendation (SR) Consideration Report.

The objective and scope of this analysis is to identify and analyze retrieval and transport methods affected by recent changes to system design criteria. The methods and retrieval equipment designs developed in this analysis will be to a conceptual level sufficient to confirm the viability of the system and the compatibility with other interdependent systems, procedures, and methods. This analysis will address changes to previous concepts for the following major retrieval or recovery conditions: Normal Retrieval, Abnormal Retrieval, and Recovery of a Contaminated Waste Package (CRWMS M&O 1999a).

According to *Waste Emplacement/Retrieval System Description Document* (CRWMS M&O 2000f, Section 1), the term "recovery" is used to indicate selective removal of a small set of waste packages (WPs) from the underground. The term "retrieval" is used to indicate removal of groups of WPs or the entire inventory of WPs from underground. Semantically, there is a difference between retrieval and recovery. However, this analysis will use the term retrieval to address both retrieval and recovery under normal, abnormal, and/or contaminated conditions.

This analysis has been prepared in accordance with the requirements set forth in the development plan entitled *Retrieval Equipment and Strategy for WP on Pallet* (CRWMS M&O 1999a). In November of 1998, the *Retrieval Equipment and Strategy* analysis (CRWMS M&O 1998a) was issued to conceptually define the preferred system for the retrieval of WPs from an emplacement drift, under normal and abnormal conditions. That analysis was based on the equipment and requirements for the Viability Assessment (VA) design concept.

Since the initial issuing of the *Retrieval Equipment and Strategy* analysis (CRWMS M&O 1998a), several significant changes have been made to the emplacement concept with resulting changes to the design criteria. The most notable changes are in response to the Enhanced Design Alternative II (EDA II) effort and the resulting SR design for the emplacement concept. The EDA II changes include emplacement drift invert design modifications, WP spacing, and an increased source-term dose rate. The latest SR emplacement concept, as presented in the *Bottom/Side Lift Gantry Conceptual Design* (CRWMS M&O 2000a), includes changes to the equipment that is designed to handle and emplace WPs. The WPs are handled and stored on dedicated pallets and are collectively known as WP/pallet assemblies.

In general, there will be no significant effect on the waste handling operations and the normal retrieval concept. Normal waste retrieval operations will be the reverse of the waste emplacement operations. Therefore, the basic operations for normal retrieval remain unaffected by these changes.

In the context of EDA II and SR design changes, the primary difference between the previous retrieval analysis and this retrieval analysis are design enhancements to the emplacement drift layout, the mobile equipment, and the materials of construction within the drift. Fundamental changes to the repository design from the VA concept to the EDA II and SR concept that affect the emplacement and retrieval conceptual design are identified below:

- The shape and orientation of most emplacement drift turnouts has been revised, however, the basic emplacement drift configuration remains unchanged.
- Each WP will now be transported and emplaced on a dedicated emplacement pallet, and therefore, the need for pre-installed WP supports has been eliminated.
- The base material of construction in the emplacement drifts has changed from concrete to steel with granular ballast as a fill material.
- The WP transporter has been reconfigured to provide for simplified, more reliable loading and unloading functions.
- The Emplacement Gantry, also known as the Bottom/Side Lift Gantry (see Sections 4.1.3 and 6.1.2.4), has been redesigned to emplace and retrieve the new WP/pallet assembly. However, the previous design option for WP carry-over is no longer applicable with the current design.

2. QUALITY ASSURANCE

This document was prepared in accordance with AP-3.10Q, *Analysis and Models.*

The quality assurance classification of repository structures, systems, and components has been performed in accordance with QAP-2-3, *Classification of Permanent Items.* The WP retrieval system has been classified as a QL-1 item by *Classification of the MGR Waste Retrieval System* (CRWMS M&O 1999b, Section 7).

This design activity has been evaluated in accordance with QAP-2-0, *Conduct of Activities.* The activity evaluation (CRWMS M&O 1999f) addressing the Quality Assurance classification has determined that this design activity is quality-affecting and subject to the requirements of the *Quality Assurance Requirements and Description* document (DOE 2000).

The process for ensuring accuracy and completeness of data was performed in accordance with AP-SV.1Q, *Control of the Electronic Management of Data.* An evaluation of this work activity was performed and was shown to be not applicable.

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3. COMPUTER SOFTWARE AND MODEL USAGE

The Project-standard suite of office automation software for word processing has been used in the preparation of this analysis. The remaining figures have been drawn using various CAD software programs and are used solely for visual display of equipment designs. These software programs are exempt from qualification as stated in Sections 2.1.1 and 2.1.5 of AP-SI.1Q, *Software Management*.

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4. INPUTS

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.

4.1 DATA AND PARAMETERS

4.1.1 The general design of the WPs, including diameter, length, and lifting features, is extracted from *Outline Dimensions, Unit Weights and External Features for all WPs to be Emplaced* (CRWMS M&O 1999c). This general information is used in Sections 6.1, 6.1.2, 6.1.2.1, and 6.2.1.

4.1.2 The general design of the WP pallet is based solely on *Outline Dimensions, Unit Weights and External Features for all Possible Waste Package (WP) Pallets to be Emplaced* (CRWMS M&O 1999d), and is used throughout Section 6.1 and in Section 6.2.1.

4.1.3 The general design of the bottom/side lift gantry, as described in *Bottom/Side Lift Gantry Conceptual Design* (CRWMS M&O 2000a, Section 6.1), is used in Sections 6.1 and 6.2.1.

4.1.4 The general design of the WP Transporter, as described in *Waste Package Transport and Transfer Alternatives* (CRWMS M&O 2000b, Sections 6.4 and 7.3), is used in Sections 6.1 and 6.2.1.

4.1.5 The general design of the Waste Emplacement/Retrieval control system, as described in *Instrumentation and Controls for Waste Emplacement* (CRWMS M&O 2000g, Sections 6.1 through 6.10), is used in Section 6.1.2.6.

4.1.6 Table 1 presents relevant dimensions and quantities of WPs for design analyses that have been baselined. This information is used throughout Section 6.3 for determining an approximate surface area for the emplaced WP.

Table 1. Dimensions and Numbers of WPs

Description	Length (m)	Diameter (m)	Maximum Number of WPs[a]	
			Design Inventory	Full Inventory
21 PWR AP/CR[b]	5.17	1.64	4600	5810
44 BWR AP[b]	5.17	1.67	3000	3750
5 DHLW/DOE SNF Short[c]	3.59	2.11	1100	1410
Naval SNF Long[d]	6.07	1.95	100	170

Notes: [a]Source: *Subsurface Facility System Description Document* (CRWMS M&O 2000h, Table 1 (Design Inventory) and Table 2 (Full Inventory)).

[b]Source: *Design Analysis for UCF Waste Packages* (CRWMS M&O 2000i, Attachment I and II).

[c]Source: *Design Analysis for the Defense High-Level Waste Disposal Container* (CRWMS M&O 2000j, Table 8).

[d]Source: *Design Analysis for the Naval SNF Waste Package* (CRWMS M&O 2000k, Attachment II).

4.1.7 The general design of the Emplacement Drift shall utilize steel inverts and the invert ballast material shall be granular (CRWMS M&O 2000d Sections 1.2.1.9 and 1.2.1.11). This information is used throughout Section 6 for determining an approximate surface area for the emplaced WP.

4.2 CRITERIA

4.2.1 The system shall segment debris (e.g., failed ground support materials and rock) into pieces no greater than TBD mm or TBD kg.
(used in Sections 6.2.4 and 6.2.6) [CRWMS M&O 2000f, 1.2.1.12]

4.2.2 The system shall remove debris from the underground up to the maximum sizes of individual pieces of TBD mm and TBD kg.
(used in Sections 6.2.4 and 6.2.6) [CRWMS M&O 2000f, Section 1.2.1.13]

4.2.3 The System shall be capable of transporting and emplacing WPs at the annual throughput TBD.
(used in Assumption 5.2) [CRWMS M&O 2000f, Section 1.2.1.4]

4.2.4 The system shall be designed to install temporary ground support to facilitate recovery and retrieval operations.
(used in Section 6.2.6) [CRWMS M&O 2000f, Section 1.2.1.14]

4.2.5 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.
(used in Section 6.2.4 and 6.2.5) [CRWMS M&O 2000f, Section 1.2.1.16)

4.2.6 The system shall be designed such that components susceptible to radiation can withstand and operate in the radiation environment TBD in which the component is located. (used in Section 6.1.2.6) [CRWMS M&O 2000f, Section 1.2.3.1]

4.2.7 The system shall be designed to withstand and operate in the extreme subsurface temperature environment of 7 degrees Celsius to 50 degrees Celsius.
(used in Section 6.1.2.6) [CRWMS M&O 2000f, Section 1.2.3.4]

4.2.8 The portions of the system supporting retrieval, recovery, and restoration shall have an operational life of 135 years after initiation of waste emplacement.
(used in Sections 6.1.3 and 6.2.3) [CRWMS M&O 2000f, Section 1.2.1.2]

4.2.9 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.
(used in Sections 6.1.3 and 6.2.3) [CRWMS M&O 2000f, Section 1.2.1.3]

4.2.10 The system shall be designed to retrieve all emplaced WPs within 34 years after the initiation of retrieval operations.
(used in Section 6.1.3) [CRWMS M&O 2000f, Section 1.2.1.5]

4.2.11 The system shall be designed to emplace and retrieve a minimum of 14,870 WPs.
(used in Section 6.1.3) [CRWMS M&O 2000f, Section 1.2.1.6]

4.2.12 The system shall be capable of transporting retrieved WPs to the Waste Handling Building (WHB) and to a storage area located up to 4 kilometers (km) (2.5 miles) directly north of the WHB.
(used in Section 6.1.3) [CRWMS M&O 2000f, Section 1.2.1.11]

4.2.13 The portions of the system supporting emplacement shall have an operational life of 40 years following the start of emplacement.
(used in Assumption 5.2) [CRWMS M&O 2000f, Section 1.2.1.1]

4.2.14 The system shall be designed to recover WPs from an emplacement drift that has blocked ventilation. (used in Section 6.2.6) [CRWMS M&O 2000f, Section 1.2.1.15]

4.2.15 The system shall be capable of performing recovery from either end of an emplacement drift. (used in Section 6.2.4) [CRWMS M&O 2000f, Section 1.2.1.17]

4.2.16 The system shall provide containment of radionuclides during WP transfer from the emplacement drift to the surface.
(used in Section 6.2.4 and 6.3.4) [CRWMS M&O 2000f, Section 1.2.1.18]

4.2.17 The system shall re-rail and restore to normal operation, if practical, any derailed system equipment. (used in Section 6.2.4) [CRWMS M&O 2000f, Section 1.2.1.22]

4.2.18 The system shall transport to the surface any system equipment that cannot be re-railed and restored to normal operation.
(used in Section 6.2.6) [CRWMS M&O 2000f, Section 1.2.1.23]

4.2.19 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.
(used in Section 6.2.4) [CRWMS M&O 2000f, Section 1.2.2.1.4]

4.2.20 The system shall operate with an electrical power feed provided by the Subsurface Emplacement Transportation System at both ends of an emplacement drift.
(used in Section 6.1.2.4) [CRWMS M&O 2000f, Section 1.2.4.12]

4.2.21 The system shall comply with the applicable provisions of "Standards for Protection Against Radiation" (10 CFR 20).
(used throughout Section 6.3) [CRWMS M&O 2000f, Section 1.2.6.1]

4.2.22 The system shall emplace WPs within each emplacement drift a minimum of 10 cm between the ends of adjacent WPs.
(used in Section 6.1.2.4)[CRWMS M&O 2000f, Section 1.2.1.9)

4.2.23 The system shall comply with the applicable assumptions contained in the "Monitored Geologic Repository Project Description Document."
(used in Section 6) [CRWMS M&O 2000f, Section 1.2.6.12]

4.2.24 The system shall be designed in accordance with the project ALARA (as low as is reasonably achievable) program goals (TBD) and the applicable guidelines of "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low as is Reasonably Achievable" (Regulatory Guide 8.8)
(used in Section 6.3.1) [CRWMS M&O 2000f, Section 1.2.2.1.9]

4.2.25 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.
(used in Section 6.3.4) (CRWMS M&O 2000f, Section 1.2.1.21]

4.2.26 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.
(used in Section 6.3.4) [CRWMS M&O 2000f, Section 1.2.1.25]

4.3 CODES AND STANDARDS

This section provides a list of the codes and standards used in this analysis.

4.3.1 American National Standards Institute/Health Physics Society

ANSI/HPS N13.12-1999

4.3.2 Code of Federal Regulations

10 CFR 20	Energy: Standards for Protection Against Radiation (used in Sections 6.3.1 and 6.3.2.1)

10 CFR 835	Energy: Occupational Radiation Protection (used in Sections 6.3.1 and 6.3.2.1)
40 CFR 61	Protection of Environment: National Emission Standards for Hazardous Air Pollutants (used in Section 6.3.1)

4.3.3 Nuclear Regulatory Commission

Regulatory Guide 1.86, Rev. 0. 1974	*Termination of Operating Licenses for Nuclear Reactors.* Washington, D.C.: U.S. Nuclear Regulatory Commission (used in Sections 6.3.1, 6.3.1.1.1, and 6.3.1.1.2).

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5. ASSUMPTIONS

The assumptions listed below are taken to be true or representative in the absence of direct confirming data or evidence. Included in each assumption is a statement addressing whether the need for further confirmation is required.

5.1 Not all WPs will have the same dimensions. In addition, it is assumed that WPs of different dimensions will be emplaced according to a schedule that mixes the different types of WPs destined for any particular emplacement drift. Therefore, the use of a weighted-average surface area is appropriate and is calculated based on the anticipated numbers and dimensions of those WP designs for which a design analysis exists. Section 6.3.1.1 calculates the areas using Equation 10 for the four WP designs listed in Table 1. Each area is multiplied by the number of WPs for each design (from Table 1), summed, and then divided by the total number of WP in all four designs. This is done for both the design inventory and the maximum inventory case. The highest of the two weighted averages (maximum inventory case) results in an average WP surface area of 31.3 m^2, which will be assumed for this analysis. However, the WPs for which baselined designs have been completed cover more than 50 percent but less than 100 percent of total number of WPs expected to be deployed. Based on the dimensions of the specific WP types, inclusion of additional baselined designs would alter the weighted average surface area by no more than 5 percent, which would have no significant impact on the calculation of surface contamination limits, and therefore, further confirmation is not required.

5.2 The maximum annual WP emplacement rate is assumed to be 605 WPs per year for this analysis. Such a high rate of WP emplacement may not be sustainable over the several years it would take to achieve the buildup and equilibrium in the release of surface contamination from multiple WPs. Therefore, this assumption is considered very conservative.

This assumed emplacement rate (Criteria 4.2.3) is based on the emplacement criteria of 14,870 WPs (Criterion 4.2.11). If the actual emplacement period is assumed to be 32 years, out of the 40 years of operational life (Criterion 4.2.13) following the start of emplacement, the emplacement rate equates to 465 WPs per year. Assuming a 30 percent increase for a peak emplacement rate provides an upper bounding limit of 605 WPs per year, and therefore, further confirmation is not required (used in Section 6.3.1.1).

5.3 Volume 1 of the DOE Handbook on *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* (DOE 1994, p. 4-101) specifies that 4×10^{-5}/hr represents a bounding airborne release rate for a homogeneous bed of powder exposed to ambient conditions (normal process facility ventilation flow or less). This resuspension rate is assumed to be conservative for this analysis when applied to removable contamination on a WP surface. It is used to derive the effective release fraction of surface contamination from emplaced WP surfaces. This assumption provides an upper bounding limit for airborne release rates and, therefore, further confirmation is not required (used in Section 6.3.1.1).

5.4 For this analysis, any contamination that is resuspended from a WP is assumed to be exhausted from the Monitored Geologic Repository (MGR) during the year following its release. This assumption (used in Section 6.3.1.1) is conservative, since any net deposition of resuspended contamination onto MGR drifts and equipment surfaces would reduce the concentration in the exhausted air. This, in turn, would result in higher allowable surface contamination limits for the WP surfaces. This assumption provides a bounding limit for contamination limits and, therefore, further confirmation is not required.

5.5 The document, *Overall Subsurface Ventilation System* (CRWMS M&O 2000e, Section 5.3), establishes the design range of ventilation airflow rates for each exhaust shaft. In this analysis, the lower bound of the design range, 800 m^3/s, at one exhaust shaft is used to estimate the amount of dilution in exhaust air for resuspended WP surface contamination. This assumption provides a lower bounding limit for ventilation airflow rates and, therefore, further confirmation is not required (used in Section 6.3.1.1).

6. ANALYSIS/MODEL

6.1 NORMAL RETRIEVAL

The focus of this section of the analysis is to identify and analyze the impact upon normal retrieval equipment and procedures by the EDA II and SR changes to the VA design criteria.. These changes are due to the following:

- Revision to emplacement drift invert design (Section 4.1.7)
- Revised spacing for WP emplacement (Criterion 4.2.22)
- Revised emplacement gantry design (Section 4.1.3)
- Revised WP transporter design (Section 4.1.4)
- Revision to the WP design and handling method (Section 4.1.1)
- The use of a dedicated pallet for WP handling and emplacement (Section 4.1.2)

These changes affect the normal retrieval operations that occur within the emplacement drift and the emplacement drift transfer dock areas. Normal retrieval operations that occur within the main drifts, turnouts, ramps and surface systems are not affected by these changes. The retrieval procedures for the events that are not affected by these changes are covered in Section 7.1 of the *Retrieval Equipment and Strategy* analysis (CRWMS M&O 1998a) and will not be repeated in this document.

As required by Criterion 4.2.23, the design of the Waste Emplacement/Retrieval System (WERS) shall comply with the applicable assumptions contained in the "Monitored Geologic Repository Project Description Document." The controlled project assumptions (CPA 004, CPA 005, CPA 019, and CPA 020) are inherent to the conceptual design of this system.

6.1.1 Definition of Normal Retrieval

As stipulated, the retrieval system retrieves to the surface all emplaced WPs or a group of WPs under normal conditions. The system also retrieves to the surface individually selected emplaced WPs under normal and abnormal conditions. The term "retrieval" is used to indicate removal of a group of WPs or the entire inventory of WPs from underground. As used in this section, "normal conditions" will refer to a subsurface environment that is performing as expected; "abnormal conditions" will refer to subsurface conditions that have been disturbed in some way (CRWMS M&O 2000f, Section 1). Thus, normal retrieval is the act of transporting WPs on their dedicated pallets from the subsurface facility emplacement drifts to the surface under normal operating conditions. Normal operating conditions stipulate that all significant systems, structures, and components that make up the subsurface facility are capable of performing their intended functions. Conditions are normal when they are consistent with repository design.

6.1.2 General Procedures and Equipment

The WERS is responsible for transporting the WP/pallet assemblies from the WHB and emplacing the WP/pallet assemblies within the emplacement drifts. This system is also charged with providing the capability and resources to retrieve the WP/pallet assemblies from their emplacement drift locations and to transport the WP/pallet assemblies back to the WHB or other selected surface facility. The waste handling equipment is designed for dual-purpose operations so that the same equipment may be used to emplace and retrieve WP/pallet assemblies. As defined in this analysis, the specialized abnormal retrieval equipment and the normal emplacement/retrieval equipment is designed to accommodate various WP and pallet sizes and weights, as defined in Section 4.1.1 and 4.1.2.

The typical retrieval process will be as follows (CRWMS M&O 2000f, Summary Section and CRWMS M&O 2000b, Section 6.1.1):

1. The WP(s) will be selected for retrieval. WPs will be identified by emplacement drift and location within the drift. All prior WP/pallet assemblies must be relocated.

   For example: A WP/pallet assembly, currently emplaced midway in the emplacement drift, is selected for recovery. The WERS would be required to relocate all WP/pallet assemblies prior to reaching the selected WP/pallet assembly. These WP/pallet assemblies would be relocated to a nearby empty emplacement drift, and then returned to the original emplacement drift after the selected WP/pallet assembly has been recovered.

2. The emplacement gantry will be transported to the selected emplacement drift on the gantry carrier, as further described in *Retrieval Equipment and Strategy* (CRWMS M&O 1998a, Section 7.1.2.4.1). Utilizing the same procedure that was used to emplace the WP/pallet assembly, the gantry will lift the WP/pallet assembly off the steel invert.

3. The gantry will transport the WP/pallet assembly to the emplacement drift transfer dock and lower the WP/pallet assembly onto the transporter roller-supported bed plate, which is located on the extended deck of the transporter, known as the transporter transfer deck (see Section 6.1.2.5).

4. The transporter rigid chain drive system will move the loaded bed plate into the transporter shielded enclosure.

5. The transporter locomotives will then transport the WP/pallet assembly, contained within the transporter, up the North Ramp to the WHB or other selected surface facility.

For the WERS, only the emplacement drift gantry, the gantry carrier, and the transporter have been affected by the design changes to the VA design. The conceptual design of the emplacement drift gantry and the WP transporter have been documented in separate analyses, as discussed in Sections 6.1.2.4 and 6.1.2.5, respectively.

6.1.2.1 WP Configuration

The emplacement/retrieval equipment has been designed to accommodate the full range of proposed WPs, as defined in Section 4.1.1. The physical structure of the WP, including length, diameter, weight, and surface geometry, sets the specific requirements the equipment must accommodate. The retrieval equipment defined in this analysis is designed to accommodate all WPs, as specified in Section 4.1.1.

As discussed in Section 6.1.2.3, normal retrieval will accommodate WP/pallet assemblies that were emplaced within the emplacement drifts. Under normal conditions, all WPs to be retrieved will be on their respective pallets and correctly positioned within the drift, i.e., the WP/pallet assemblies have not shifted or dislodged from their original emplacement position. During normal retrieval activities, all lifting and maneuvering of the WP/pallet assemblies will be done by the bottom/side lift gantry, which only contacts the WP pallets. Therefore, normal retrieval will not require or utilize any specific surface feature(s) of the WP, and thus, no direct contact with the WP is required (CRWMS M&O 2000a, Section 6.1). The emplacement/retrieval equipment needs only to accommodate the weight and outside geometry of the WP/pallet assembly.

6.1.2.2 Emplacement Drift Invert and Ground Support

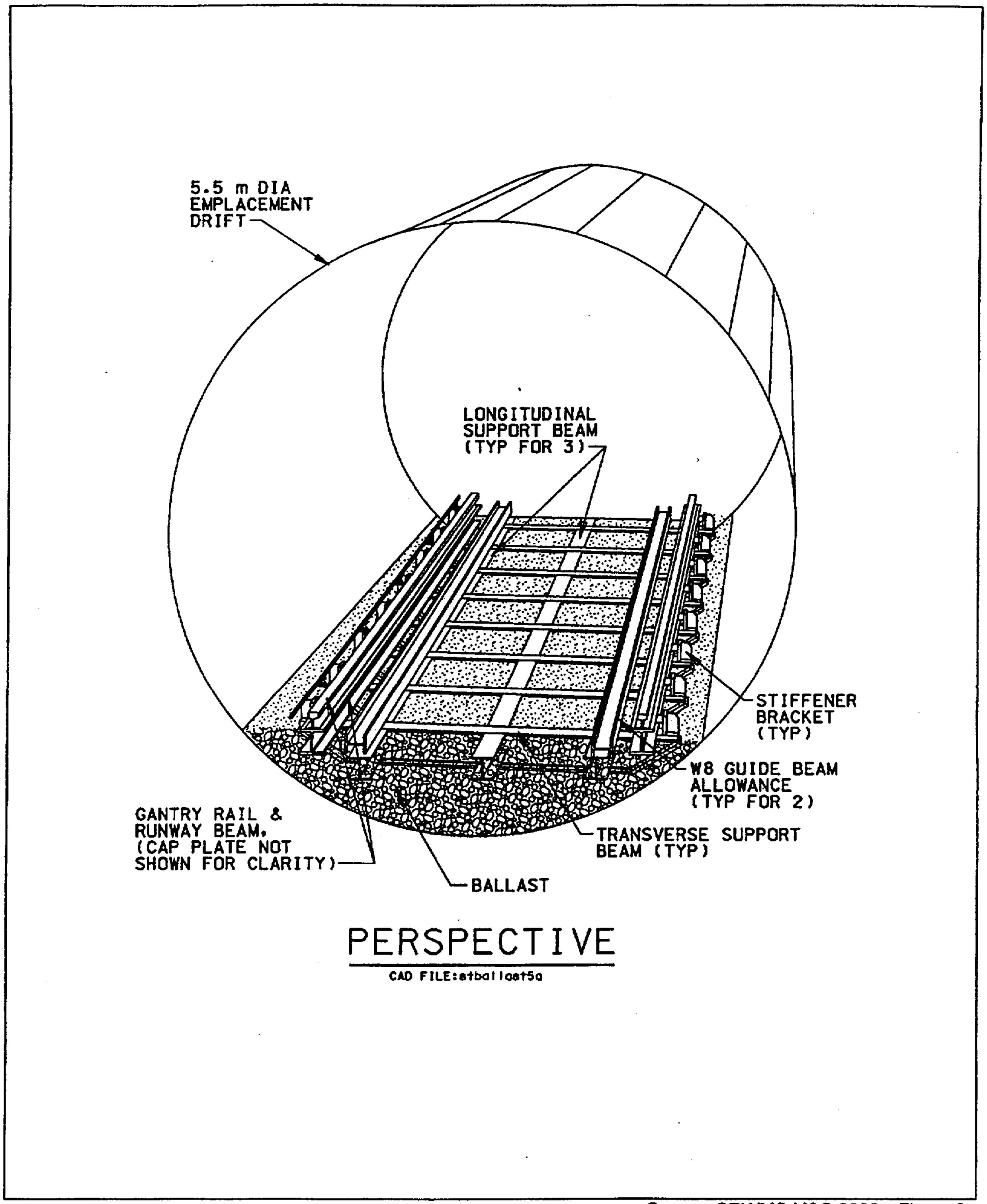
With the current emplacement concept, the WP/pallet assembly rests directly on the emplacement drift invert. The pallet will support the WP during the emplacement period and will rest directly on the structural steel invert frame. Additionally, the steel invert may support the potential drip shield and any other associated WERS or post-closure equipment, as required. A perspective view of the steel invert is shown in Figure 1.

Granular ballast material will be placed in and around the steel members of the invert to an elevation not to exceed the top of the longitudinal and transverse steel support beams (Section 4.1.7). This ballast level will insure that the pallets and the potential drip shields do not rest on the ballast material, but are fully supported by the steel invert beams. Compaction of the ballast material should be sufficient to consolidate the material to the point that settlement of the ballast over time will not be significant and in an amount that limits the future backfill, if required, from migrating under the bottom of the potential drip shield.

The previous retrieval analysis, *Retrieval Equipment and Strategy* (CRWMS M&O 1998a, Section 4.3.9), assumed that concrete inverts would be used in the emplacement drifts. All emplacement/retrieval equipment referred to in this analysis is fully compatible with the current emplacement drift design, which utilizes steel inverts and granular ballast material (Section 4.1.7). By definition, normal retrieval will be conducted on steel inverts with granular ballast that is fully within the specified system configuration. The same equipment that initially placed the WP/pallet assemblies within the emplacement drifts will be fully capable and directly designed to perform normal retrieval on the steel inverts. Abnormal events that have an impact on the use of steel inverts and ballast material are addressed in Section 6.2.

6.1.2.3 Pallet Use

Each WP will be transported and emplaced while resting on a dedicated pallet. The design of the pallet, with the V-shape feature, holds the WP securely by gravity alone and without the need for straps or other attachment features. The pallet supports the WP while in the WHB, during transport, and within the emplacement drift. The pallet will also support the WP during retrieval.



Source: CRWMS M&O 2000c, Figure 6

Figure 1. Steel Invert with Ballast

Each WP that has to be retrieved will remain on its specific pallet during normal retrieval operations, including removal from the emplacement drift, transport to the surface, and placement at a pre-specified surface facility. The pallet also provides a support structure that the emplacement/retrieval equipment can engage in order to lift and move the WP without coming in direct contact with the WP. The design of the pallet is illustrated in Figure 2, and is based on information from Section 4.1.2.

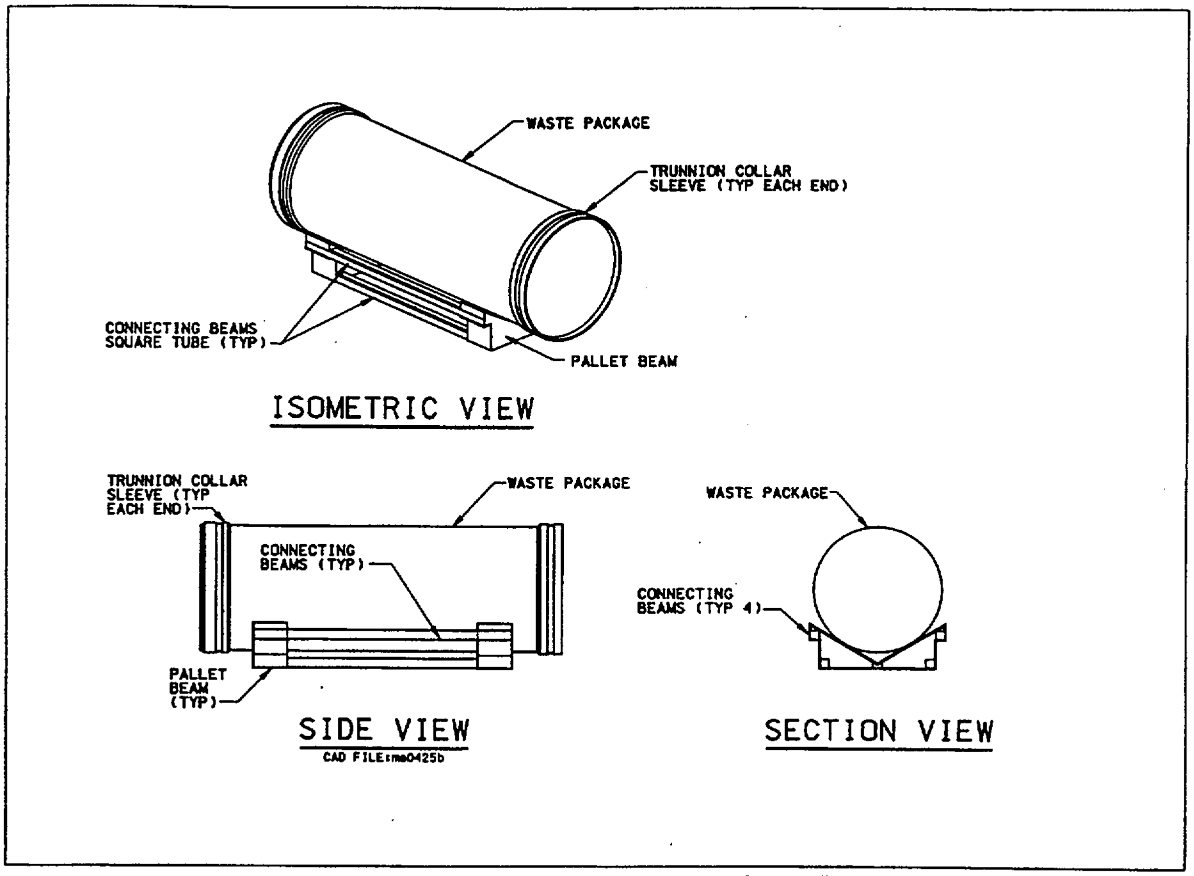
6.1.2.4 Bottom/Side Lift Gantry

Normal retrieval of WP/pallet assemblies from the emplacement drifts will be performed using the bottom/side lift gantry that was used to emplace the WP/pallet assemblies within the drift. The bottom/side lift gantry is a rail-mounted, self-propelled, remotely operated apparatus designed to emplace and retrieve WP/pallet assemblies within the emplacement drift. A conceptual-level perspective of the bottom/side lift gantry is shown in Figure 3.

Based on the VA design, the gantry design has been revised to utilize the bottom/side lift feature, rather than the end-lift concept that was used in the VA design. This change was necessary to comply with the revised WP spacing of 10 cm within the emplacement drift (Criterion 4.2.22) and the use of dedicated pallets for WP handling (Section 4.1.2). Specific details of the design concept and operating parameters of the bottom/side lift gantry can be found in the *Bottom/Side Lift Gantry Conceptual Design Analysis* (CRWMS M&O 2000a).

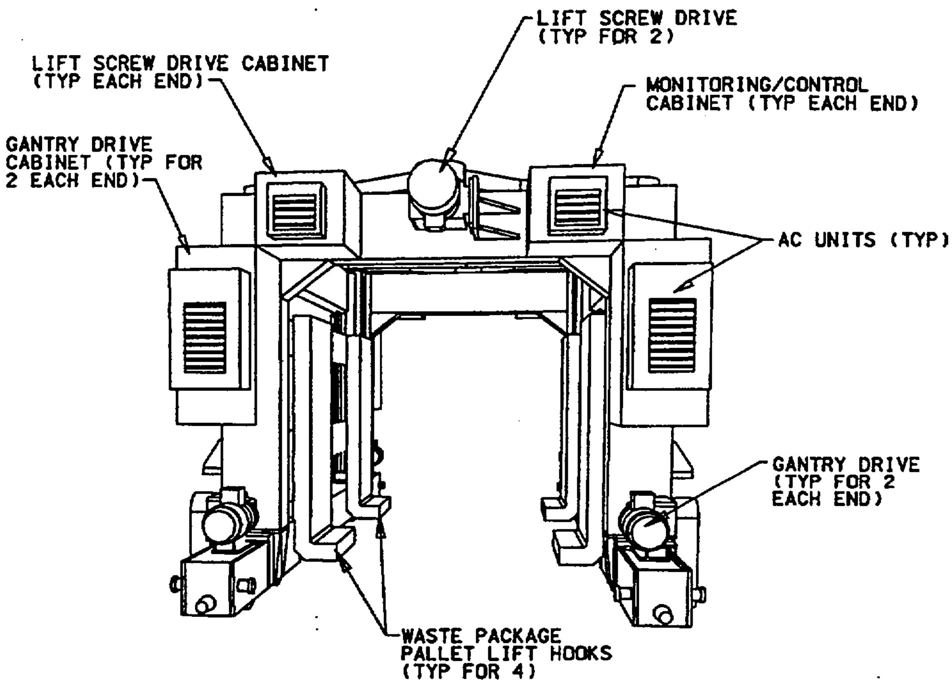
For normal retrieval, a WP/pallet assembly slated for retrieval resides in a normal state in an emplacement drift. The bottom/side lift gantry would be transported on a gantry carrier to the specific emplacement drift (CRWMS M&O 1998a, Section 7.1.2.4.1). The bottom/side lift gantry is supported during travel on a pair of elevated rails when on-board the gantry carrier and is powered by a third rail electrical system. The third rail receives power at both ends of an emplacement drift by the Subsurface Emplacement Transportation System (Criterion 4.2.20). The elevated rails mate with the emplacement drift transfer dock track when the gantry carrier is docked at the entrance to an emplacement drift, known as the emplacement drift transfer dock. After the carrier is docked, the bottom/side lift gantry transfers off the gantry carrier rails and onto the emplacement drift gantry track. With the emplacement drift isolation doors opened, the gantry will travel to the first WP. The gantry straddles the WP/pallet assembly, as illustrated in Figure 4. The bottom/side lift gantry then raises its lifting hooks to engage the pallet structure such that the pallet and its accompanying WP are lifted vertically off the drift invert. The loaded gantry then travels to the emplacement drift transfer dock, located at the entrance of the drift.

Following the retrieval of the WP/pallet assembly from the emplacement drift, the gantry will place the assembly onto the transporter roller-mounted bed plate, located at the transporter transfer deck. The rigid-chain drive system on the transporter will then pull the WP/pallet assembly into the transporter shielded enclosure. The transporter shielded enclosure doors will be closed prior to exiting the emplacement drift transfer dock and transported to the surface (see Section 6.1.2.5).



Source: CRWMS M&O 1999c and CRWMS M&O 1999d

Figure 2. WP and Pallet

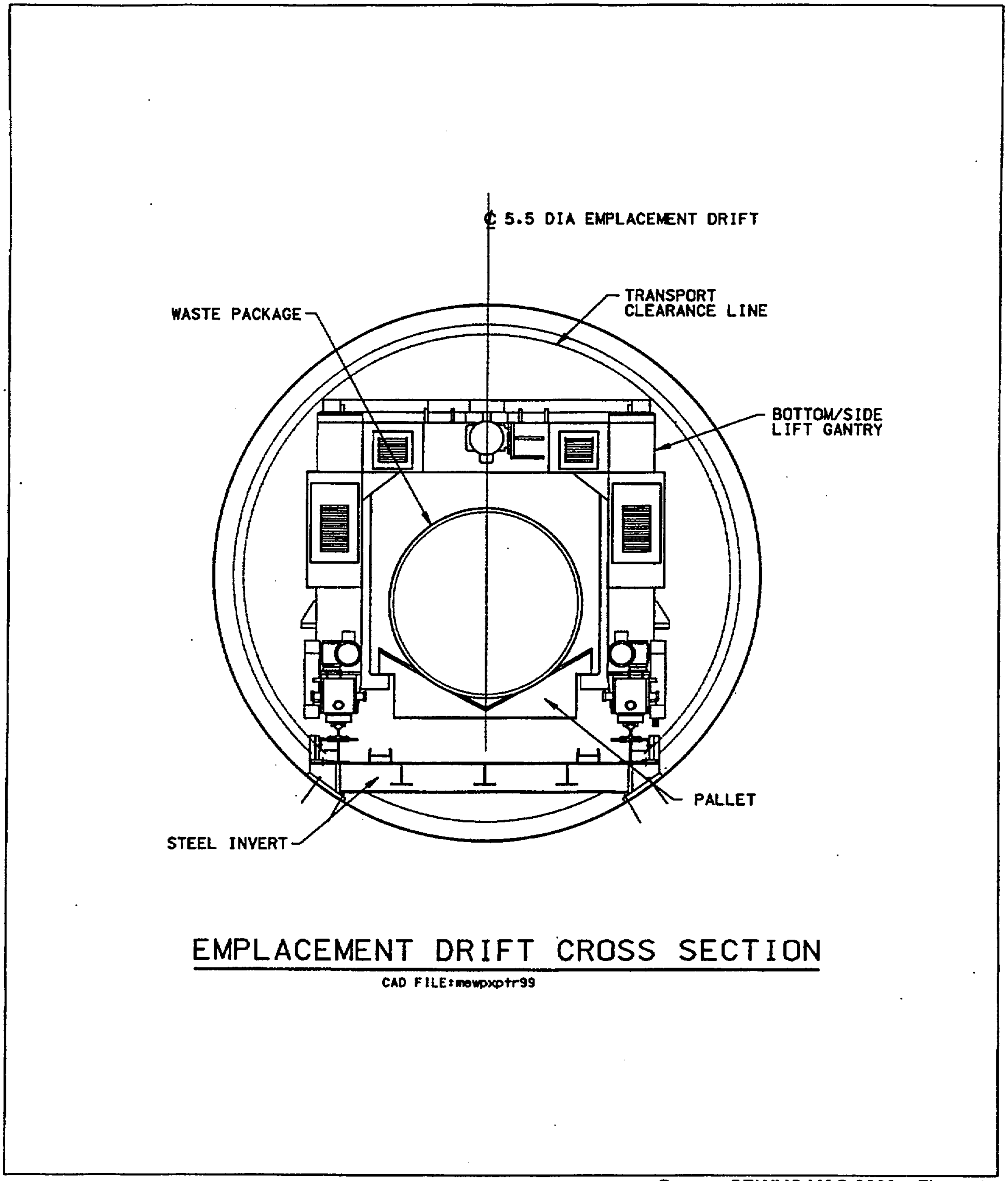


ISOMETRIC VIEW

CAD FILE:megantry99

Source: CRWMS M&O 2000a, Figure 7

Figure 3. Bottom/Side Lift Gantry Perspective



Source: CRWMS M&O 2000a, Figure 4

Figure 4. Drift Cross-Section with Gantry

The WP is unshielded during retrieval from the emplacement drift by the bottom/side lift gantry. Radiation levels in these areas will be high and personnel access will be restricted to avoid radiation exposure. Therefore, the bottom/side lift gantry will be operated by remote control (see Section 6.1.2.6).

WP/pallet assemblies must be removed in reverse order from how they were emplaced. Because of the clearance restrictions within the drift, a gantry carrying a WP/pallet assembly cannot lift the assembly over the top of another emplaced WP (CRWMS M&O 2000a, Section 6.3). Therefore, to retrieve a WP located toward the center of a drift, all WP/pallet assemblies between the emplacement drift transfer dock and the target WP will need to be retrieved.

6.1.2.5 WP Transporter

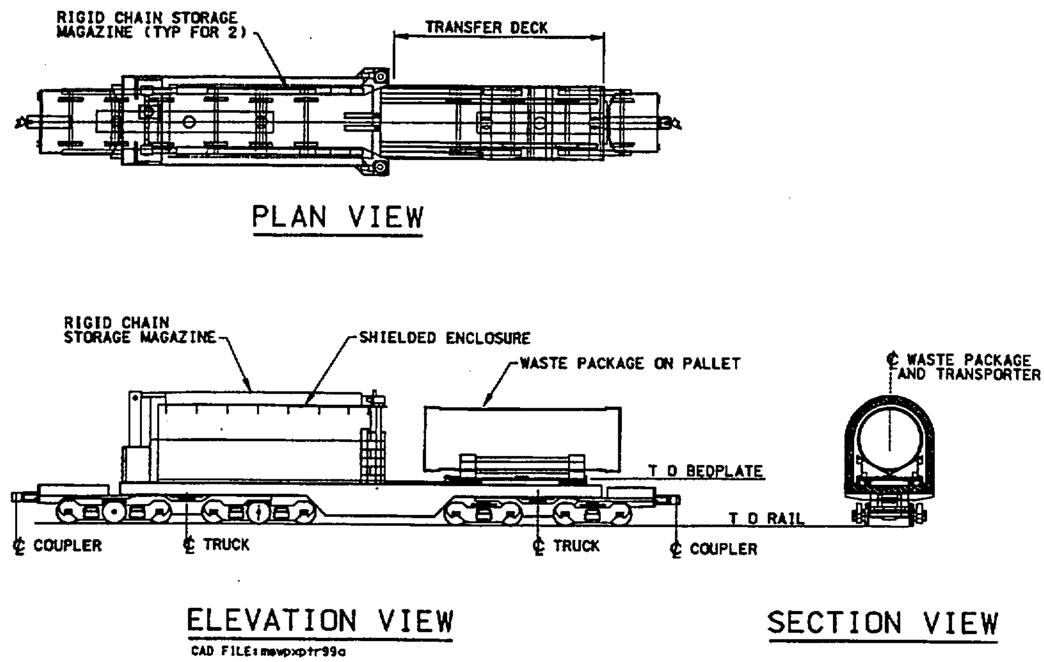
Several different WP transporter systems were reviewed in the *Waste Package Transport and Transfer Alternatives Analysis* (CRWMS M&O 2000b). As stated in Section 7.3 of that analysis, the transporter with transfer deck is recommended as the preferred concept. Therefore, for this retrieval analysis, the transporter with transfer deck is the transporter design that is used in the emplacement and retrieval process (Section 4.1.4).

During retrieval operations, the transporter with transfer deck configuration provides a workable method for transferring the WP/pallet assembly from the bottom/side lift gantry to the transporter and from the transporter to the selected surface facility. This configuration combines the shielded transporter enclosure and the staging and access functions of the dock into a single, common-frame, rail car. The WP transporter with transfer deck is illustrated in Figure 5.

In preparation for WP retrieval, the empty WP transporter will be moved to the emplacement drift turnout by two locomotives, on fore and one aft of the WP transporter. One locomotive disconnects from the transporter, and the remaining locomotive moves the transporter into the emplacement drift turnout. The WP transporter shielded enclosure doors are opened and the roller-supported bed-plate is moved to the transfer deck portion of the transporter for receipt of a WP/pallet assembly. The emplacement drift isolation doors are opened, and the locomotive then positions the transporter at the emplacement drift transfer dock.

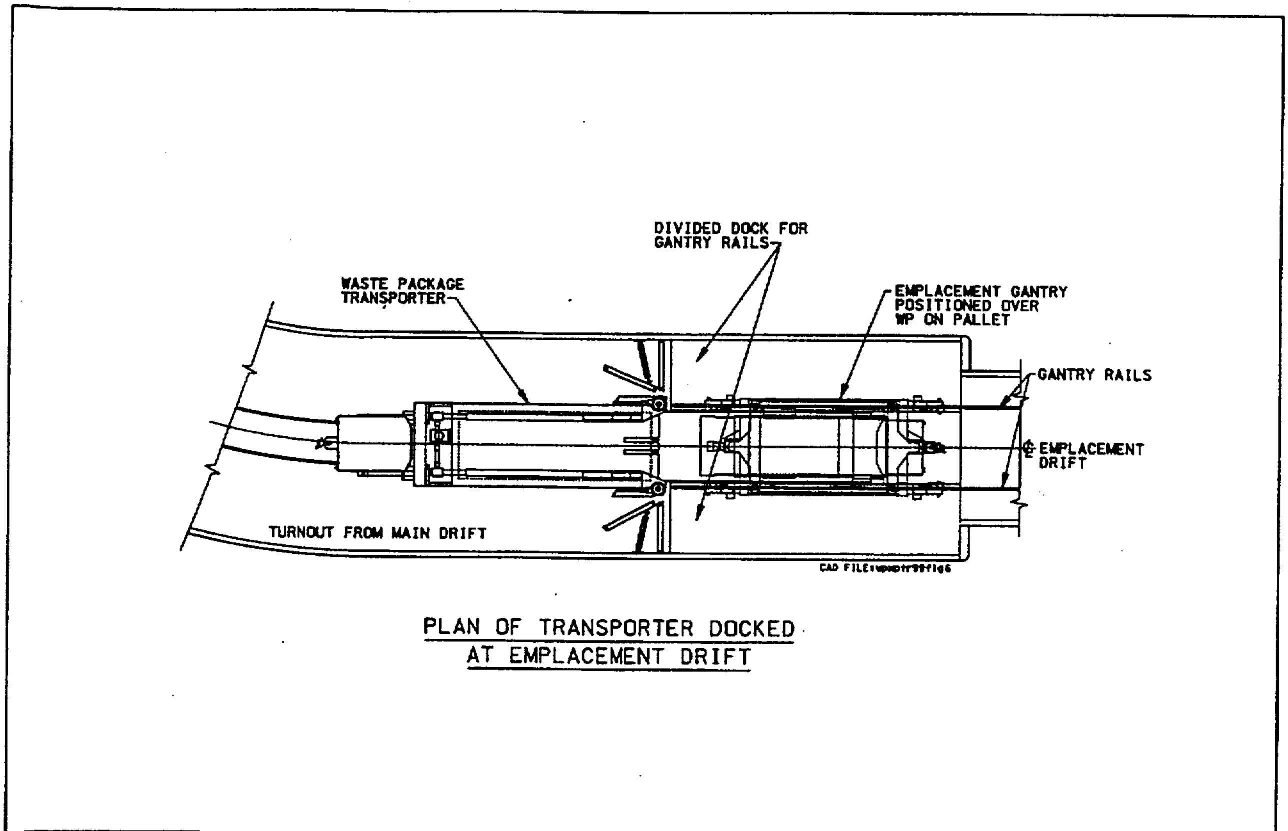
The emplacement drift transfer dock has been designed with a U-shape feature to accept the transporter transfer deck. The top of the emplacement drift transfer dock is at a height slightly above the top of the transporter transfer deck. The gantry rails are installed on top and on both sides of the emplacement drift transfer dock and permit the gantry to place a WP/pallet assembly onto the roller-supported bed-plate without having to board the transporter, as illustrated in Figure 6.

Continuing with the retrieval sequence, the rigid-chain drive system will move the bed plate with the WP/pallet assembly into the shielded enclosure portion of the transporter. The locomotive will pull the transporter out of the emplacement drift transfer dock, and while within the emplacement drift turnout, the transporter shielded enclosure doors and the emplacement drift isolation doors are closed. The locomotive will then move the loaded transporter out of the emplacement drift turnout for re-coupling with the second locomotive.



Source: CRWMS M&O 2000b, Figure 3

Figure 5. Transporter with Transfer Deck



Source: CRWMS M&O 2000b, Figure 19

Figure 6. Transporter Docked at Emplacement Drift

The two locomotives will move the transporter through the main drift and up the North Ramp to the surface facility designated for that WP. After the WP/pallet assembly has been deposited at the surface facility, the locomotives with transporter will travel back into the repository to retrieve another WP, if required. Further details of the WP transporter design concept and operating methods can be found in the *Waste Package Transport and Transfer Alternatives* (CRWMS M&O 2000b).

6.1.2.6 Remote Operation, Monitoring, and Control

The mobile rail equipment used for waste retrieval within the emplacement drift is among the most critical components of the WERS. The equipment will be designed to operate within the high-temperature, high-radiation environment inside the emplacement drifts (Criteria 4.2.6 and 4.2.7). While in the emplacement drifts, these vehicles will be controlled exclusively by operators at a remote control console located at the surface (See Section 4.1.5).

The design of the waste retrieval equipment and their control systems must impose limitations on system complexity if they are to perform their intended functions in a highly reliable manner. Control system reliability will be further enhanced by incorporating high-quality hardware and software components. These components mainly include dual-redundant control computers, instrumentation, and data communications equipment. Design strategies, such as employing diverse technologies, physically separating redundant components, and providing backup data communication systems, will be implemented to ensure fault-tolerant operation.

The waste retrieval equipment will utilize one of several alternative mobile communication technologies in order to transmit and receive data for its remote monitoring and control functions. A number of different technologies currently available have been examined and evaluated by an earlier design analysis (CRWMS M&O 2000g, Section 6.5.3). For various reasons indicated in the referenced analysis, the technologies being considered for the vehicle data communication system include direct radio, leaky feeder, and slotted microwave guide systems. Due to the critical need for reliable data communication systems for these vehicles, the current design approach will be to implement dual-redundant systems on the vehicle. Thus, each mobile rail vehicle will be capable of interfacing with remote operators over two completely different, and separate, communications networks (CRWMS M&O 2000g, Section 6.5.3).

6.1.3 Retrieval Strategy

Retrieval of WPs may be required because of the development of potential risk to public health and safety or because of the increased value of resources from the spent nuclear fuel. WPs may also be removed for control of repository operations, such as thermal loading balance, emplacement drift maintenance, performance confirmation (WP sampling), and process/material deficiency.

Assuming normal conditions exist, all WPs could be removed within 34 years after initiation of the retrieval operation by following a similar, but reversed, emplacement sequence (Criterion 4.2.10). The WERS would be used to retrieve WPs, under normal conditions, without additional equipment or procedures, since retrieval is essentially the same as emplacement, but with the steps completed in reverse order. And, under normal conditions, the retrieval system would be able to retrieve a minimum of 14,870 WPs (Criterion 4.2.11) WPs within 34 years after the initiation of retrieval operations (Criterion 4.2.10) by following the same emplacement rate as described in Assumption 5.2.

The system would have an operational life of 135 years following the start of waste emplacement (Criterion 4.2.8). In addition, the system would have to support a deferral of closure for up to 300 years (Criterion 4.2.9). The conceptual level design of the retrieval equipment provides little opportunity to include provisions that support a deferral of closure for such an extended time period. In reality, providing 300 years of capability (Criterion 4.2.9) is much more of an inspection, testing, and extended maintenance issue than a design issue. Maintaining an extended capability would require a substantial, on-going equipment maintenance program including periodic replacement of time-sensitive parts, such as seals, hydraulic systems, lubricants, etc. Any decision to defer closure for such an extended time would require significant planning and procedures for effective WERS fleet management and equipment replacement to provide the desired capacities.

Normal retrieval will require interfacing with several other systems (CRWMS M&O 2000f, Summary Section). These interfaces may include, but are not limited to:

- The Subsurface Facility System and the Ground Control System for the size and layout of the underground openings.
- The Subsurface Ventilation System for the emplacement drift operating environment and the size of the drift isolation doors.
- All WP and pallet types for the size, weight, and other important parameters affecting retrieval operations.
- The Subsurface Emplacement Transportation system for the rail system and the distribution of power through the rail system.
- The MGR Operations Monitoring and Control System for the transmission of data to and from the retrieval system equipment, and for remote control of system equipment.
- The Disposal Container Handling System, WHB system, and/or other surface facilities for the receipt of retrieved WP/pallet assemblies.

WPs that are returned to the surface during normal retrieval would be transported by rail to the WHB or to a storage area located less than 4 km (2.5 miles) directly north of the WHB (Criterion 4.2.12). The retrieval system utilizes rail and rail-mounted equipment for both emplacement and retrieval operations, which accommodate these travel distances. The surface facility requirements for processing the retrieved WPs are out of the scope of this analysis.

Retrieval criteria state that portions of the system supporting retrieval and restoration shall include provisions that support a deferral of closure for up to 300 years after initiation of waste emplacement (Criterion 4.2.9). The emplacement and retrieval fleet will be designed and built to provide extended operational life capabilities. As previously mentioned, providing 300 years of operation is more of a maintenance and equipment replacement issue than a design issue. Any decision to extend closure for such an extended time will require significant planning to provide an acceptable maintenance and periodic equipment replacement policy.

6.2 ABNORMAL RETRIEVAL

6.2.1 General

The focus of this section of the analysis is to identify and analyze the affect upon abnormal retrieval equipment and procedures by the recent EDA II and SR changes affecting the VA design criteria. These changes are due to the following:

- Revision to emplacement drift invert design (Section 4.1.7)
- Revised spacing for WP emplacement (Criterion 4.2.22)
- Revised emplacement gantry design (Section 4.1.3)
- Revised WP transporter design (Section 4.1.4)
- Revision to the WP design and handling method (Section 4.1.1)
- The use of a dedicated pallet for WP handling and emplacement (Section 4.1.2)

These changes affect the retrieval operations that occur in the emplacement drift and emplacement drift transfer dock areas. The mitigation strategy of abnormal events requiring abnormal retrieval in the main drifts, turnouts, ramps and surface systems is not affected by these changes. The retrieval equipment for these specific events is covered in the *Retrieval Equipment and Strategy* analysis (CRWMS M&O 1998a, Section 7.2) and will not be revisited in this document.

6.2.2 Identification of Abnormal Retrieval Events

Abnormal retrieval conditions result when one or more abnormal events occur before or during normal emplacement, caretaking, or retrieval operations. Abnormal events may be the result of an unpredicted process occurring within the repository that hinders normal retrieval. The affected mitigation strategies related to abnormal retrieval have been identified below, and are those mitigation strategies that have been affected by the EDA II and SR changes to the emplacement equipment design and to the emplacement drift invert design.

The redesign of the WP transporter, which was developed in *Waste Package Transport and Transfer Alternatives* (CRWMS M&O 2000b, Section 6.4), has an effect on the mitigation procedure for a WP that is immobilized on the transporter deck. This change is discussed in Section 6.2.7. The redesign of the emplacement gantry, as described in *Bottom/Side Lift Gantry Conceptual Design* (CRWMS M&O 2000a, Section 6.1), has an effect on the mitigation procedure required for the condition when the emplacement gantry WP lifting mechanism fails. This is discussed in Section 6.2.5. Table 2, which was developed in *Retrieval Events Evaluation* (CRWMS M&O 1999e, Section 6.4.2), is a list of abnormal events that would require additional evaluation of mitigation procedures.

Table 2. Abnormal Events Potentially Affected

Emplacement gantry derailment – normal speed
Emplacement gantry derailment – gantry runaway
Emplacement gantry WP lifting mechanism fails
Rockfall and/or ground support collapse onto WP – static rockfall
Rockfall and/or ground support onto WP – seismic induced

To eliminate redundancy in the mitigation strategy discussion for each of these scenarios, only the most complex event was selected to "bound" the others. For example, of the five abnormal events listed in Table 2, the two emplacement gantry derailment events are grouped together and the related effects are discussed in Section 6.2.4. The two rockfall and/or ground support collapse events are addressed in Section 6.2.6. And, as mentioned above, the mitigation procedure for a gantry lifting mechanism failure is addressed in Section 6.2.5.

6.2.3 Strategy and Mitigation Steps for Abnormal Retrieval Conditions

The WERS remediates abnormal events involving the portion of the system that supports waste emplacement and retrieval (CRWMS M&O 2000f, Section 1.1.14). The portion of the WERS that supports retrieval and restoration shall have an operational life of 135 years after the initiation of waste emplacement (Criterion 4.2.8). The portions of the system supporting retrieval and restoration shall include provisions that support a deferral of closure for up to 300 years after initiation of waste emplacement (Criterion 4.2.9).

As previously discussed, the conceptual level design of the retrieval equipment provides little opportunity to "include provisions that support a deferral of closure" for such an extended time period. In reality, providing 300 years of capability is much more of an inspection, testing, and extended maintenance issue than a design issue. Maintaining an extended capability would require a substantial, on-going equipment maintenance program including periodic replacement of time-sensitive parts, such as seals, hydraulic systems, lubricants, etc. Any decision to defer closure for such an extended time would require significant planning and procedures for effective WERS fleet management and equipment replacement to provide the desired capacities.

The strategy for the mitigation of all abnormal conditions consists of the following activities:

- Assessing nuclear and non-nuclear safety
- Establishing access control and isolating the event area from continued operations, if required
- Confining contamination, if present
- Collecting critical technical data, other than nuclear
- Formulating a mitigation plan
- Designing and providing any additional specialized equipment needed for mitigation
- Implementation of the mitigation plan

The mitigation concepts for abnormal events described in this analysis do not include every detail of the mitigation process. For example, rail track-mounted equipment may not pass other rail track-mounted equipment, as there is only one set of tracks within the North Portal, main drifts (CRWMS M&O 1999g, Figure 9), and the emplacement drifts (see Figure 1). When one piece of equipment finishes its task, it must generally be removed from the drift before another piece of equipment can be transported to the site of the abnormal condition. All WERS equipment will be operated using remote control systems as described in Section 6.1.2.6 during retrieval.

6.2.4 Emplacement Gantry Derailment

The purpose of this section is to develop a recovery concept for an abnormal condition that deals with a derailed or otherwise immobilized gantry within an emplacement drift. At the time of the derailment, the gantry may be with or without the load of a WP/pallet assembly.

The specific cause of a gantry derailment within an emplacement drift is of less concern than the mitigation of the actual derailment. However, the derailment may be due to misalignment of the gantry track and/or other unforeseen obstructions on or near the gantry rails.

Methods to recover the gantry from abnormal and/or design basis events include measures to place and release loads (e.g., a WP/pallet assembly) in a safe manner (Criterion 4.2.19). The retrieval system shall have the ability to clear and remove rock, ground support, failed equipment, and debris, which could impede retrieval operations (CRWMS M&O 2000f, Section 1.1.6) (Criterion 4.2.2). To accommodate these criteria, two pieces of retrieval equipment were conceptually developed in the *Retrieval Equipment and Strategy* analysis (CRWMS M&O 1998a, Section 7.2). These were:

- Emplacement Drift Gantry Carrier, shown in Figure 7 (CRWMS M&O 1998a, Section 7.2.5.10)

- Multipurpose Hauler, shown in Figure 8 (CRWMS M&O 1998a, Section 7.2.5.12)

Both pieces of equipment would operate on steel rollers and the temporary steel plates, which are placed on the invert system between the gantry rails. The current design for the invert is the modified steel invert with ballast (see Sections 4.1.7 and 6.1.2.2). Although the equipment designed in the *Retrieval Equipment and Strategy* analysis (CRWMS M&O 1998a, Section 7.2) assumed a concrete invert, the conceptual design of these pieces of equipment is still valid by the temporary installation of steel plates onto the invert during the recovery process of the failed equipment. Installation of the steel plates on top of the steel invert and ballast would be performed by the multipurpose hauler, which will allow the emplacement drift gantry carrier and the multipurpose vehicle to operate as designed (CRWMS M&O 1998a, Sections 7.2.5.7 and 7.2.5.12).

There would be two major alternatives for the rerailment of a derailed emplacement gantry:

- The use of rerailers
- The use of an Emplacement Drift Gantry Carrier

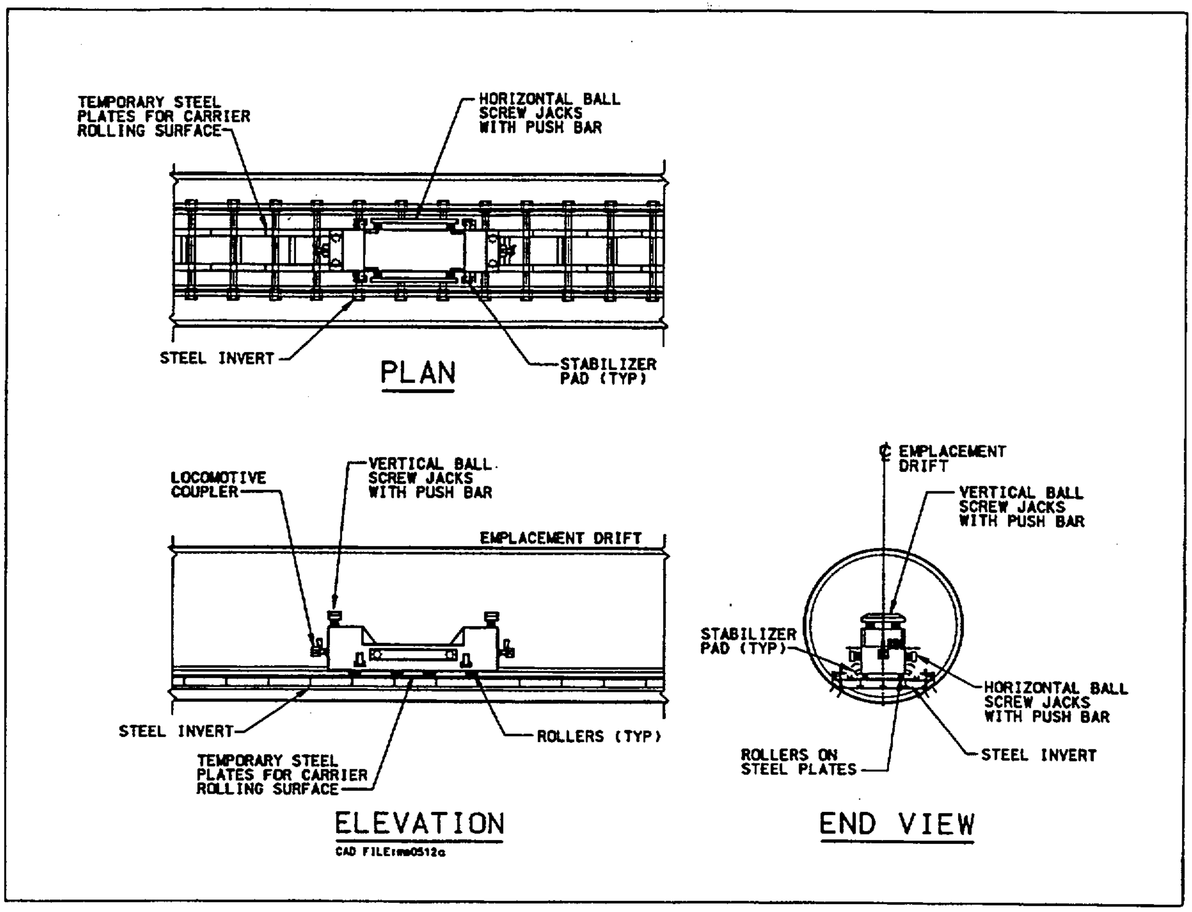


Figure 7. Emplacement Drift Gantry Carrier

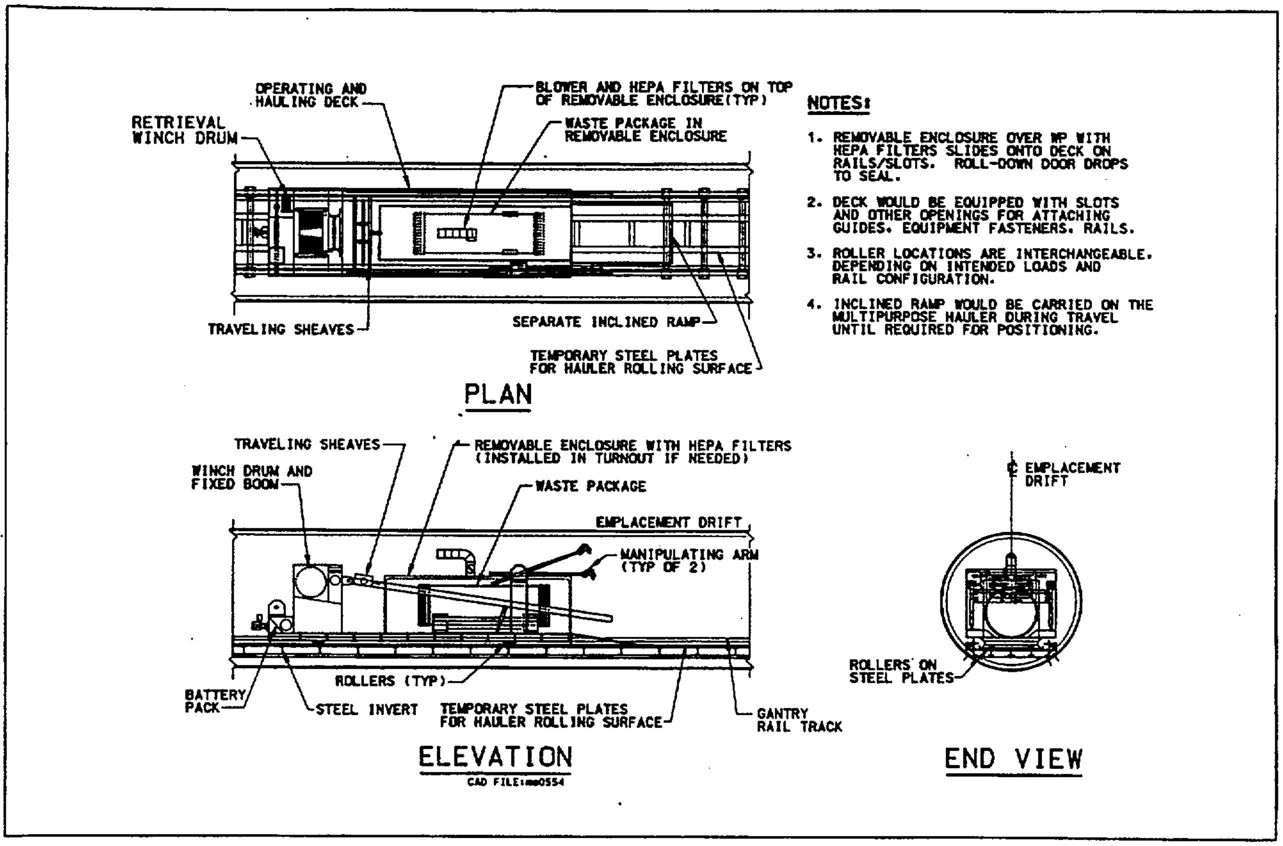


Figure 8. Multipurpose Hauler

As the name suggests, a typical rerailer is a portable device designed to rerail a railcar that has come off its track. When two rerailers, one on each track, are installed, the disabled railcar is pulled over the rerailers. The shape and design of the rerailers lift and align the rail wheels with the rail-head, as they are being rolled over the rerailer, thereby rerailing the railcar. As a single piece of equipment without any moving parts, a rerailer provides a simple and reliable means to rerail a disabled railcar.

However, adverse conditions, such as high temperatures, high radiation and limited space, may make the remote installation of rerailers difficult. Additional factors that could inhibit the use of rerailers may include:

- Excessive weight of the gantry with a WP/pallet assembly,
- Position of the emplacement gantry off the track/rail system.

If it is determined that the use of rerailers is not a viable option for the recovery of a derailed emplacement gantry, a second option, as indicated above, may be utilized. This retrieval option involves the use of an emplacement drift gantry carrier, which has been conceptually developed to recover a derailed, or otherwise disabled, emplacement gantry within the confines of the emplacement drift envelope. This specialized equipment will be designed to perform the following operations:

- Move and position itself underneath the unloaded emplacement gantry,
- Raise the emplacement gantry above the level of the gantry track,
- Align the emplacement gantry wheels with the track,
- Lower the emplacement gantry back onto the track, or completely haul the emplacement gantry in the raised position out of the emplacement drift.

The following describes a potential gantry derailment scenario and the mitigation strategy for the recovery of the disabled emplacement gantry and the WP/pallet assembly.

The scenario describes a derailed emplacement gantry within the emplacement drift while carrying a WP/pallet assembly. This derailment would occur deep within the emplacement drift, near the ventilation raise. As a result of the derailment, the emplacement drift rails under the derailed gantry are damaged beyond use, and the gantry trucks on the ventilation-raise-side are inoperable (i.e., the gantry will no longer roll). In addition, the electric third rail near the gantry is damaged, thus eliminating the electric power supply locally to the emplacement gantry. It can be determined that the use of rerailers would not be a feasible option for the mitigation of this scenario due to the damaged rail and gantry trucks.

A possible mitigation sequence may be as follows:

Because the emplacement gantry trucks closest to the ventilation shaft are damaged, these trucks must be raised off the invert and the gantry towed out of the emplacement drift. Access to the derailed emplacement gantry, near to the ventilation raise, would be accomplished by removing the WPs from the far end of the emplacement drift and the drift section between the ventilation raise and the disabled gantry (Criterion 4.2.15). WPs that may be in the way toward the disabled gantry would be removed under normal retrieval operations using a second emplacement gantry.

Should the emplacement drift design require an elevated collar on the ventilation raise and stop blocks at the end of the gantry rails, the remotely controlled multipurpose vehicle would utilize its grippers to remove these components. During these operating functions, the multipurpose vehicle would operate from the deck of the multipurpose hauler (see Figure 9), which is moved by an emplacement drift retrieval locomotive (CRWMS M&O 1998a, Section 7.2.5.6).

As described in *Retrieval Equipment and Strategy* (CRWMS M&O 1998a, Section 7.2.5.7), the multipurpose vehicle will be a relatively small unit designed to operate on level inverts in the emplacement drifts, main drift, and ramp areas, or on raised decks such as the multipurpose hauler or temporary elevated roadway sections. The multipurpose vehicle can be fitted with various individual attachments that can perform specific operations. Such attachments include, but are not limited to, a bucket attachment for removing debris, an impact hammer for reducing debris size, demolition shears for cutting steel or other tough material, or a cutting torch to dismantle damaged equipment or structures (Criterion 4.2.1).

In addition to hauling the multipurpose vehicle, the multipurpose hauler would also be used as the temporary storage platform for any components that are removed. The same equipment would then install grating and temporary rail sections over the ventilation raise, thereby connecting the rails from both sides of the emplacement drift. When the gantry rail connection has been completed, a second emplacement gantry would then be used to remove the undamaged WP/pallet assemblies, up to the derailed emplacement gantry (see Figure 10).

Due to the lack of third-rail electric power within the drift section that contains the derailed gantry, the retrieval locomotive, with on-board battery packs, would power the emplacement drift gantry carrier and any other equipment not having self-contained power sources.

The next step toward completing the recovery operations would be to separate and remove the WP/pallet assembly from the derailed gantry. The multipurpose vehicle on the multipurpose hauler (CRWMS M&O 1998a, Section 7.2.5.7 and 7.2.5.12) would restore power to the derailed gantry by connecting an electrical power and data communications cable to the auxiliary receptacle on the disabled emplacement gantry (Criterion 4.2.5). Before lowering the WP/pallet assembly, the multipurpose vehicle would place plate steel onto the ties and ballast invert surface underneath the gantry to form an elevated sliding surface. The lifting mechanism on the gantry would lower the WP/pallet assembly onto the elevated sliding surface. The multipurpose vehicle would be removed from the multipurpose hauler within the drift turnout, and the hauler would be sent back into the emplacement drift. The winch cable on the hauler would then be attached to the lower section of the pallet frame that supports the WP using the manipulator arm, and the WP/pallet assembly would be winched onto the deck of the hauler (Figure 11). Some slipping of the multipurpose hauler may occur during the winch operation. However, any slipping that may occur is insignificant to the design or operation of the hauler and would not preclude the hauler from retrieving the WP/pallet assembly. After the recovery of the WP/pallet assembly, the multipurpose hauler would be transported to the drift entrance for removal on a gantry carrier or equivalent transport car.

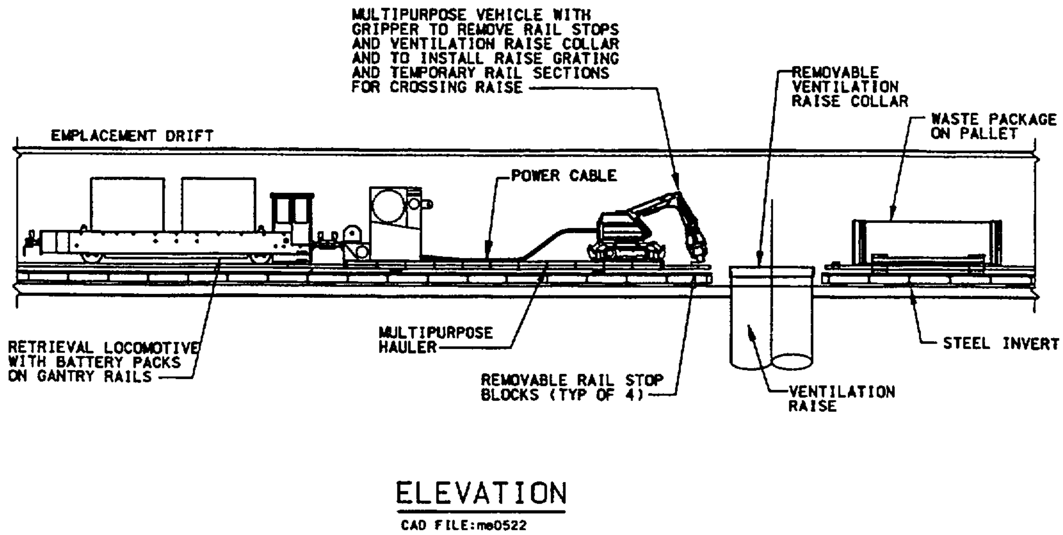


Figure 9. Multipurpose Hauler Removing Obstructions

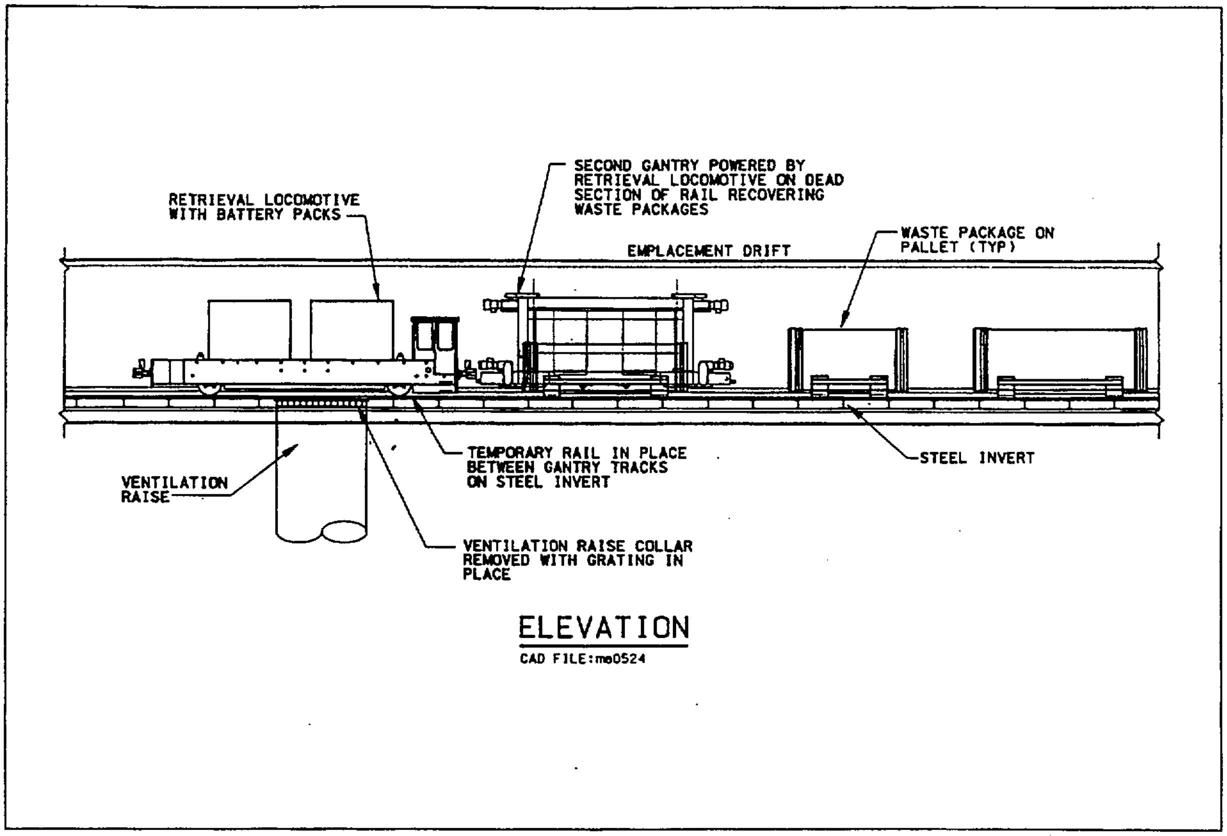


Figure 10. Second Gantry Removing WP

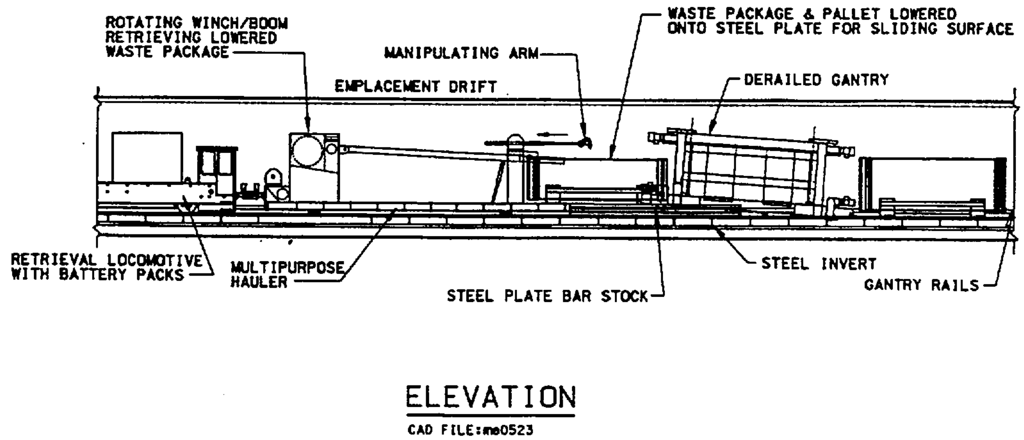


Figure 11. Hauler Retrieving Trapped WP

In the event of a breached WP, the hauler could then be equipped to accept a temporary contamination enclosure (see Figure 8). Due to limited workspace within the emplacement drift, the enclosure would be installed within the drift turnout once the hauler was clear of the emplacement drift. The ventilation airflow from the main drift, into the drift turnout, and down the emplacement drift will prevent any contamination from reaching the main drifts. However, the drift turnout has the possibility of being contaminated.

The enclosure on the multipurpose hauler would be maintained under a negative pressure (i.e., a vacuum), with a blower exhausting into a HEPA filter (CRWMS M&O 1998a, Section 7.2.5.12) (Criterion 4.2.16). The enclosure would contain any airborne contamination particles emanating from the WP, but it would not provide any radiation shielding. Due to this condition, personnel access would have to be restricted to areas at a safe distance from the WP during transit from subsurface to surface.

After the release and removal of the WP/pallet assembly from within the emplacement drift, the gantry lifting mechanism would then be raised to an elevated position to allow free access to the underside of the derailed gantry. The derailed emplacement gantry would then be removed from the emplacement drift using the emplacement drift gantry carrier (Figure 12). The following paragraph provides details for the preparation and removal of the derailed emplacement gantry.

To provide the emplacement drift gantry carrier with an even rolling surface, steel plates would be set by the multipurpose vehicle onto the invert and between the emplacement drift rails. The emplacement drift gantry carrier would be transported into the drift and placed on the steel plates using the second emplacement gantry. A retrieval locomotive would then push the emplacement drift gantry carrier into place under the derailed gantry. Stabilizer pads on the emplacement drift gantry carrier would be extended to contact the drift invert and provide the necessary stability while the vertical ball screw jacks on the emplacement drift gantry carrier would contact the gantry frame from underneath and attempt to raise it above the gantry rail.

If lifting of the gantry were not possible due to ground support interference, the horizontal ball screw jacks on the emplacement drift gantry carrier would be deployed, shifting the gantry towards the gantry rail. The derailed gantry, now clear of the ground support and emplacement drift walls, would then be raised just above the damaged tracks, aligned with the good rail track sections.

Once the gantry is aligned with the good rail track, two possible scenarios to recover the gantry from within the emplacement drift exist. These scenarios would depend on the severity of the gantry derailment.

If the gantry can be re-railed by the emplacement drift gantry carrier, as described above, and the gantry remains functional, i.e., the drive system and controls remain in working condition, the gantry would travel under its own power to the emplacement drift entrance. At the entrance, the gantry would board the gantry carrier, not to be confused with the emplacement drift gantry carrier, and moved to the surface facility for maintenance and repair.

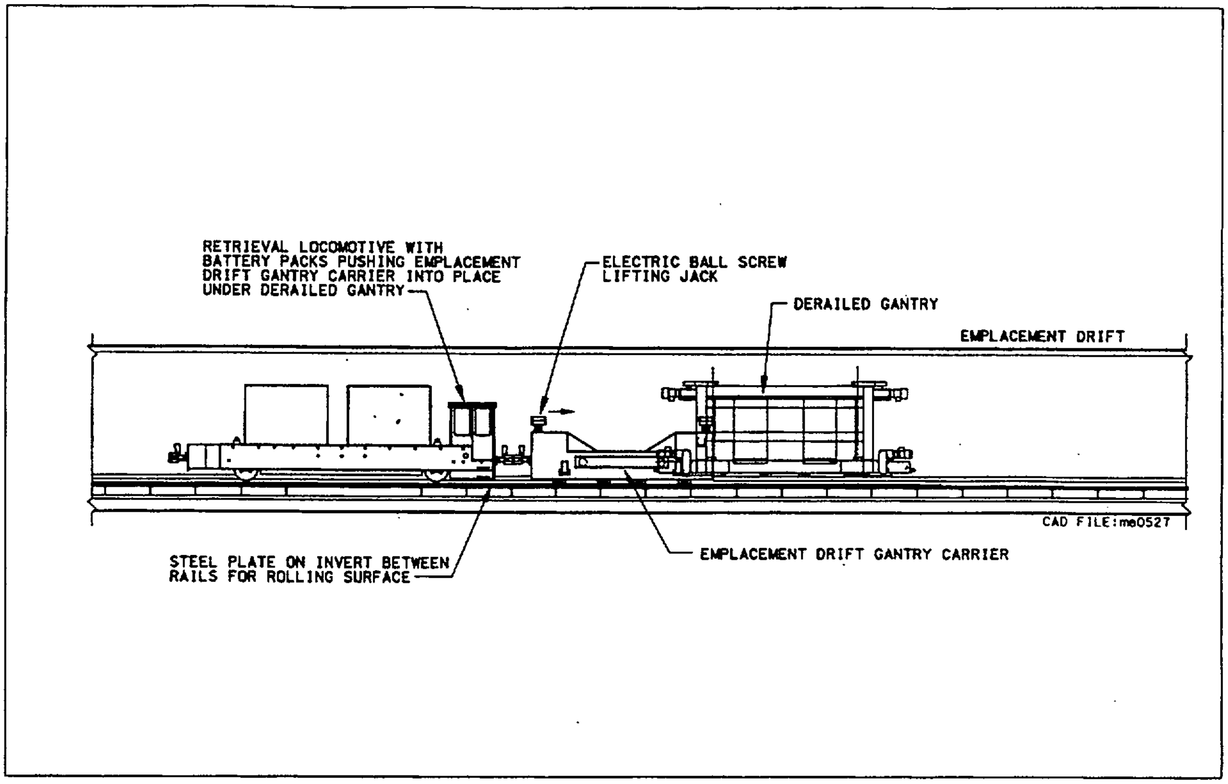


Figure 12. Emplacement Drift Gantry Carrier Pushed into Position

However, if the gantry trucks, drive mechanism, and/or control system have been severely damaged and are no longer functional, the emplacement drift gantry carrier would then be used to recover and transport the emplacement gantry to the emplacement drift entrance. The emplacement drift gantry carrier, moved by a retrieval locomotive, would raise the gantry off the rail and tow the gantry to the emplacement drift entrance, as shown in Figure 13.

6.2.5 Gantry Cannot Emplace or Retrieve WP

The following are the mitigation strategies to resolve the issue of an emplacement gantry that cannot emplace or retrieve a WP to/from an emplacement drift. One such scenario would be when an emplacement gantry, operating within the emplacement drift, is unable to engage a WP/pallet assembly for retrieval. Another possible scenario may be that the emplacement gantry cannot engage the WP/pallet assembly while on the WP transporter deck. Or, due to an electrical or mechanical failure of the gantry, a WP/pallet assembly cannot be lowered and released from the gantry lifting hooks. These scenarios could prevent the normal emplacement or retrieval of a WP/pallet assembly.

The causes for such a scenario vary, but may be due to a malfunction of the gantry lift mechanism, misalignment of a WP/pallet assembly within the emplacement drift, and/or a misalignment of a WP/pallet assembly on the WP transporter deck while at the emplacement drift transfer dock.

A mitigation strategy to recover a misaligned, off-center, or skewed WP/pallet assembly within an emplacement drift may start with an inspection of the emplacement drift. A performance confirmation gantry (CRWMS M&O 1998a, Section 7.2.5.2) would be used to inspect the affected site for rail damage, WP/pallet assembly position, and any differential settlement of the ballast material in the drift. If the abnormal condition can not be easily rectified, temporary design modifications, based on the positioning of the WP, may be considered. This may require a change to the lifting hooks of the emplacement gantry to accommodate the abnormal lifting needs. The WP/pallet assembly may be retrieved by utilizing the multipurpose hauler (Section 6.2.4) and a temporary ramp, designed to fit over the rails to the surface of the ties and the ballast (Figure 8). The winch cable(s) on the hauler would be attached to the pallet, and the WP/pallet assembly would then be pulled onto the hauler. If the first two options were not feasible, a bottom lift transporter, as described in *Retrieval Equipment and Strategy* (CRWMS M&O 1998a, Section 7.2.5.13), would be employed to remove the misplaced WP/pallet assembly.

The mitigation strategy for the scenario where a gantry cannot raise or lower a WP/pallet assembly would be very similar to the steps performed in a gantry derailment scenario, as described in Section 6.2.4. The source of such a malfunction may be due to a gantry electrical or mechanical failure of the lifting mechanism. The first step in mitigating this type of scenario would be to retrieve the WP/pallet assembly and transport the emplacement gantry to the surface for repair. An auxiliary power supply and data communication link would be connected to the gantry in an attempt to restore electrical power and communications (Criterion 4.2.5) so that the WP/pallet assembly could be lowered and the gantry moved onto the gantry carrier for transport to the surface.

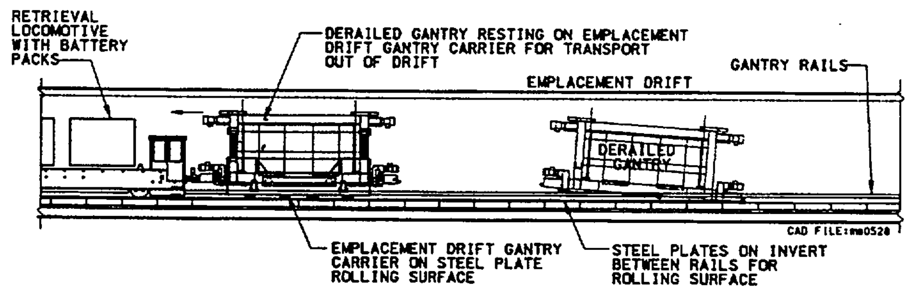


Figure 13. Emplacement Drift Gantry Carrier Moving Derailed Gantry

However, if the gantry is still unable to deposit the WP after auxiliary power and data communications has been connected, the entire emplacement gantry, complete with the WP/pallet assembly, could be loaded onto the gantry carrier and transported to the surface facilities for repair. Due to the presence of the unshielded WP and the harmful radiation effects, administrative controls would have to be established to prevent personnel radiation exposures for this type of operation.

Another possible mitigation option would be to disengage the WP/pallet assembly from the gantry while within the emplacement drift. The multipurpose vehicle and multipurpose hauler would be used to slide a raised platform underneath the raised WP/pallet assembly. The multipurpose vehicle would then attach the multipurpose hauler winch cables to the WP pallet. The entire WP/pallet assembly would be pulled off the gantry hooks and onto the installed raised platform. The gantry can now be transported to the surface for maintenance and repair. After the repaired gantry has been returned to the emplacement drift, the gantry would simply lift the abandoned WP/pallet assembly off the installed raised platform. The emplacement gantry could then continue the normal emplacement or retrieval operations.

6.2.6 Rock Fall and/or Ground Support Collapse onto a WP in an Emplacement Drift (Statically or Seismically Induced)

A rock fall or ground support collapse within an emplacement drift will require an abnormal retrieval activity to be executed for the removal of WP/pallet assemblies within the damaged drift. An example scenario would be if a portion of the ground support fails within an emplacement drift causing a total blockage of the drift (Criterion 4.2.14). To exacerbate the scenario, it can be envisioned that a loaded emplacement gantry is buried and, therefore, damaged (Figure 14). Also, repository infrastructure components, including the ground support, rail tracks, electric third rail, and communication systems are severely damaged and inoperable in the area of the abnormal event. In addition, WPs may be present in the drift, if WP emplacement has begun.

A performance confirmation gantry (CRWMS M&O 1998a, Section 7.2.5.2) or other suitable surveying equipment would be used to inspect the emplacement drift in the event that infrastructure damage was suspected. Items to be verified would include the presence of drift contamination, the emplaced WP/pallet assembly position, ground support, and condition of the drift invert and gantry tracks.

Depending on the operational status of the emplacement drift, restoration of the ventilation system may not be required in order to continue the mitigation procedures. For example, if the WP emplacement operations were underway at the time of the rock fall, the previously emplaced WPs could be removed in a reasonable amount of time. Therefore, ventilation restoration may not be required to maintain an acceptable drift temperature during the remaining retrieval and drift restoration operations.

However, if ventilation was interrupted by a drift/ground support collapse that occurred in a loaded drift midway between the emplacement drift entrance and the ventilation raise, cooling of disabled portion of the drift may be required.

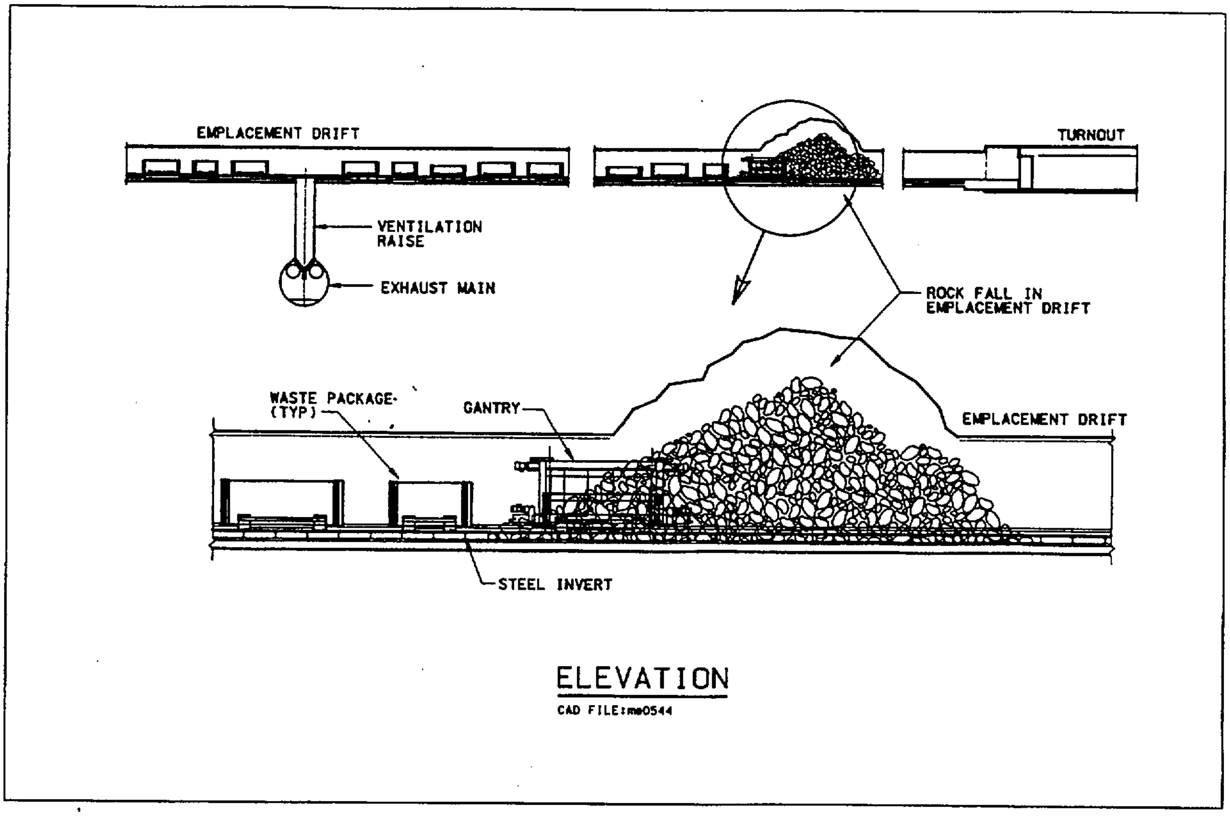


Figure 14. Rock Fall in Emplacement Drift Covering Equipment

The specific need and the extent of temporary ventilation required within damaged drift will depend on several conditions in the emplacement drift. These may include, but are not limited to:

- If both the thermal loading of the drift and the time required to mitigate and restore the emplacement drift do not allow temperatures within the drift to rise above predetermined WP limits, then it may be determined that temporary ventilation is not required.

- If the retrieval equipment can not relocate the WPs unaffected by the drift/ground control collapse prior to the drift reaching unacceptable temperature limits, then it may be determined that temporary ventilation is required.

- If the drift/ground support collapse occurs some time after the emplacement drift has been fully loaded, then temporary ventilation may be required on both sides of the collapse.

The mitigation and recovery operations would start with the normal relocation or retrieval of all WP/pallet assemblies in an adjacent emplacement drift, thereby providing access for mining equipment to tunnel into the disabled portion of the damaged emplacement drift. This would require the use of a roadheader, drill-and-blast, and/or similar mining equipment and techniques to bore the emergency drift from the adjacent drift to the damaged drift. The emergency drift would provide the required ventilation needed to cool the damaged drift section, i.e., from the rock fall area to the ventilation raise.

Prior to any boring or mining activity, the accessible emplaced WP/pallet assemblies outside the rock fall area would be removed using normal retrieval procedures, as described in Section 6.1.3. These operations would continue while the conditions in the drift remain within the specified operating range for the equipment. The WP/pallet assemblies retrieved under these conditions are those that are undisturbed, not buried by rock fall, and where the electric power supply and control system is still in working order. The WP/pallet assemblies would be removed using the same retrieval procedure and equipment under normal retrieval conditions, as described in Sections 6.1.2.4 and 6.1.3. The mobile equipment for this operation would consist of the typical emplacement/retrieval gantry without the need for additional equipment.

With these WPs removed and appropriate temporary shielding installed, it could be safe for workers to enter both the damaged and adjacent drifts in order to establish a temporary roadway for excavating equipment. The emergency drift would be bored through the pillar separating the drifts using normal underground excavation procedures. The emergency drift would be bored until just before the damaged drift wall is breached. Final access to the drift, containing the buried WPs, would be completed using remotely controlled boring equipment. The ventilation raise and the isolation doors of the drift used for boring would then be closed to permit the cooling airflow through the blocked drift section (Criterion 4.2.14). The next operation would be to retrieve WP/pallet assemblies within the damaged emplacement drift that are easily accessible but without the availability of electric power and/or a working control system, i.e., between the ventilation raise and the rock fall. This group of WP/pallet assemblies would be removed using the same retrieval procedure and equipment under abnormal retrieval conditions, as described in

Section 6.2.4. The mobile equipment for this operation would consist of the typical emplacement/retrieval gantry in conjunction with the battery powered retrieval locomotive. Therefore, electric power to operate retrieval equipment within the damaged section of the emplacement drift would be provided through the battery operated emplacement drift locomotive.

Once the rock fall area becomes accessible to the mitigation equipment, the next clean up step would be to clear remaining debris accumulation from the invert in front of the main rock fall. Enough debris would be cleared to permit the installation of temporary ground control on either side of the rock fall. Part of the retrieval system is the installation of temporary ground support to permit safe conduct of retrieval operations (Criterion 4.2.4).

Remaining WP/pallet assemblies that are partially buried and have to be recovered from underneath the rock fall would have to be removed by use of the multipurpose hauler, this too would be in conjunction with the battery powered retrieval locomotive. Removal of buried WPs would take priority over buried equipment. When a buried WP/pallet assembly becomes exposed, the winch cable on the multipurpose hauler would be attached to the lower part of the pallet and the entire WP/pallet assembly would be pulled onto the hauler. Additional equipment may include the use of the multipurpose vehicle to clear any rock and other debris to access a WP/pallet assembly. Typical details of a buried WP/pallet assembly in an emplacement drift and some of the recovery equipment are shown in Figure 15.

When all WP/pallet assemblies have been removed from the debris, work would continue to remove the remaining debris around the buried equipment, with the bucket attachment on the multipurpose vehicle (Figure 16). Other attachments required for debris size reduction would be attached as necessary, such as jack-hammers or crushers (Criterion 4.2.1). The multipurpose vehicle would be interchanged with a scaling machine (CRWMS M&O 1998a, Section 7.2.5.14) to remove loose material around the edges of the opening created by the rock fall. A muck container for the rock fall material would be placed on the deck of the hauler, next to the operating multipurpose vehicle, to reduce vehicle travel in and out of the emplacement drift (Criterion 4.2.2). Normal mining equipment and vehicles would be used to transport the muck to the surface, or other suitable site.

When all impeding debris have been removed from the damaged emplacement drift, any remaining emplacement/retrieval equipment would then be removed. If there were no breached WPs during the rock-fall and clean-up, the equipment removal may be performed manually. The method used for equipment removal would depend on the operational status of the equipment and the condition of the gantry rails. If the rails are usable and the equipment is relatively intact, the gantry may be re-railed or pulled by other means back to the emplacement drift transfer dock (see Section 6.2.4) for removal. However, if the rails are damaged beyond use and/or the equipment is not worth salvaging, fill material would be imported, as required, to fully cover the emplacement drift invert providing a road bed. This would permit access to the damaged equipment by non-rail vehicles and equipment. The damaged emplacement equipment would be dismantled or, in worst case, cut into manageable pieces and removed (Criterion 4.2.18).

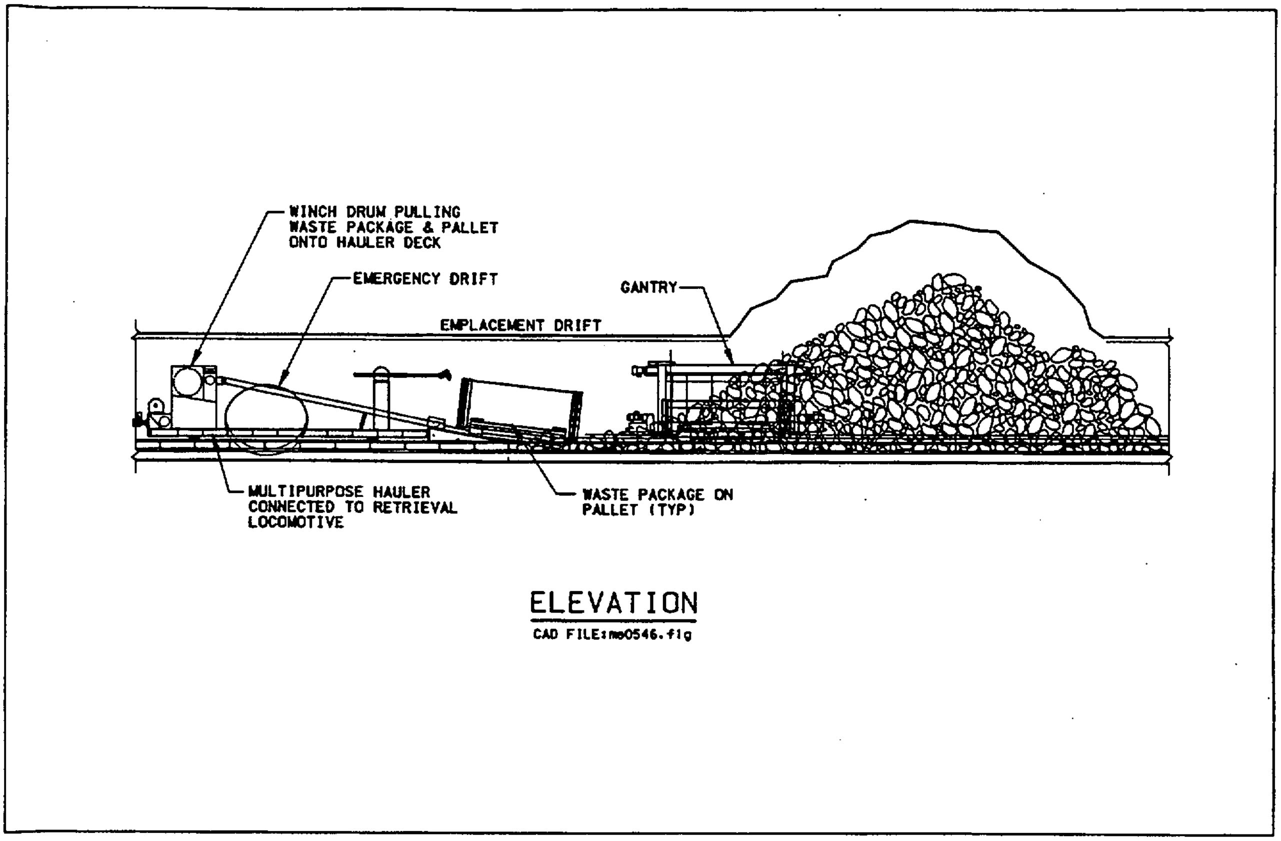


Figure 15. Multipurpose Hauler Retrieving Buried WP

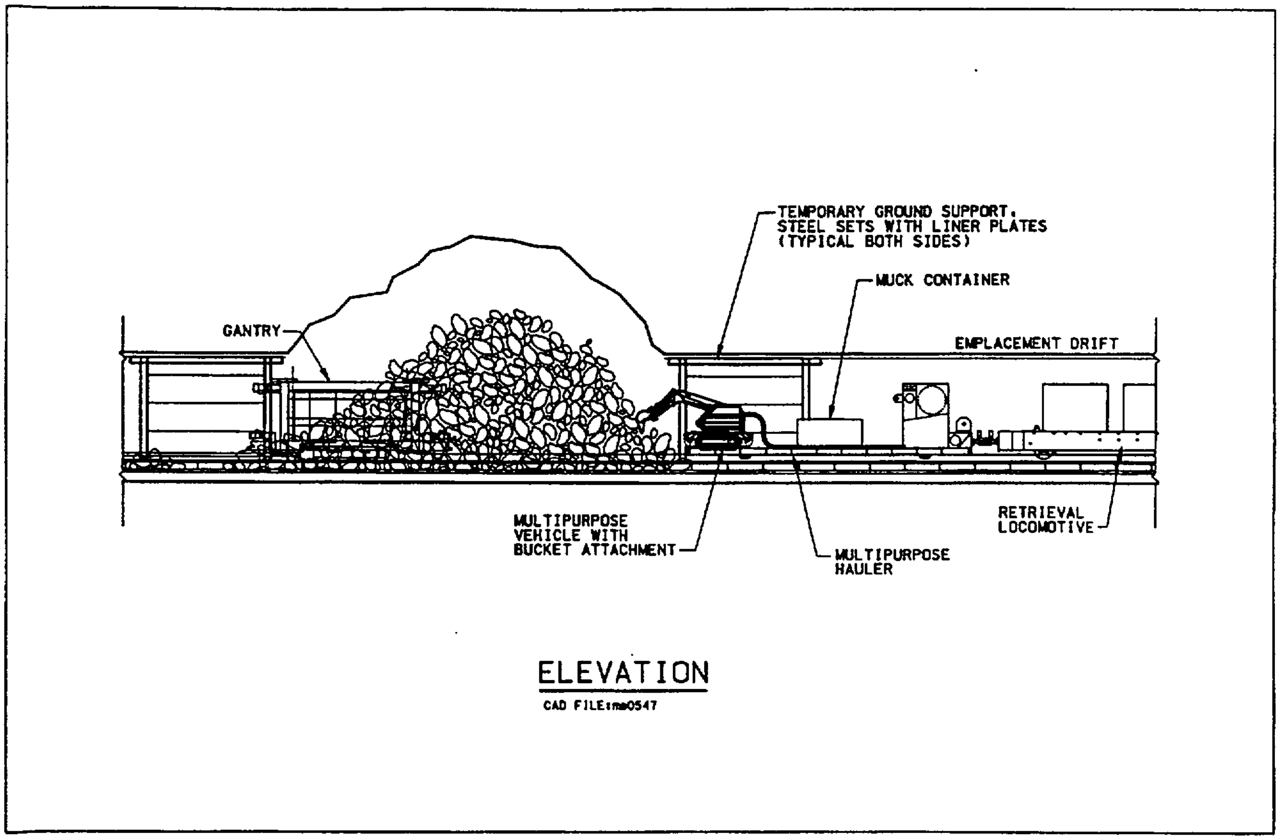


Figure 16. Multipurpose Hauler Removing Debris

Once the equipment has been removed from the drift, work may commence to rebuild the infrastructure. Additional loose material from the rock fall may have to be removed to stabilize the drift walls and crown. Further stabilization of the drift may require the use of rock bolting or other stabilization methods (see Figure 17). The ground support and related systems would then be rebuilt using normal underground construction procedures.

6.2.7 WP is Immobilized on the Transporter Deck

The following describes a potential abnormal event and the mitigation strategy at the emplacement drift transfer dock. Conceptual details regarding the configuration of the current WP transporter and the emplacement drift transfer dock were discussed in Section 6.1.2.5, as documented in a recent design analysis *Waste Package Transport and Transfer Alternatives* (CRWMS M&O 2000b).

This abnormal event is envisioned to occur at the emplacement drift transfer dock. The event consists of a WP/pallet assembly loaded on the roller-supported bed plate which malfunctions and only rolls part-way out of the shielded portion of the transporter. The bed plate, still attached to the transporter rigid chains, is immobilized and, by normal operations, cannot be pulled back into the shielded portion of the transporter nor fully extended onto the transfer deck area. This condition may be due to roller damage, foreign objects impeding movement, misalignment between bed plate and the bed plate roller retainer guide, or a malfunction of the transporter rigid chain drive system.

With the current design of the emplacement drift transfer dock area (see Section 6.1.2.5), there is very limited space between the hinges of the open drift isolation doors and WP transporter parked at the dock (see Figure 6). Therefore, access to the immobilized WP/pallet assembly on the bed plate without moving the WP transporter from the emplacement drift transfer dock may be through the emplacement drift. Because of the unshielded WP on the transporter, as well as other WPs that may already be emplaced in the drift, remote control operations would need to be used for completing mitigation.

The roller-supported bed plate is attached to the WP transporter by a horizontal bar connected to a pair of retractable rigid chains (CRWMS M&O 2000b, Section 6.8.6). Portions of the enclosures for the rigid chains between the chain-gearbox and the transporter shielding are accessible from the emplacement drift turnout. The chains would be exposed at these external locations and could be cut, dismantled, or broken, thereby freeing the bed plate from the transporter. Because of the heavy shielding provided by the bulk of the transporter, radiation levels at the back of the transporter may be sufficiently low to allow for some of the mitigating functions manually, with the use of portable shielding. Such functions may include some limited work on the rigid chain drive mechanism at the rear of the transporter.

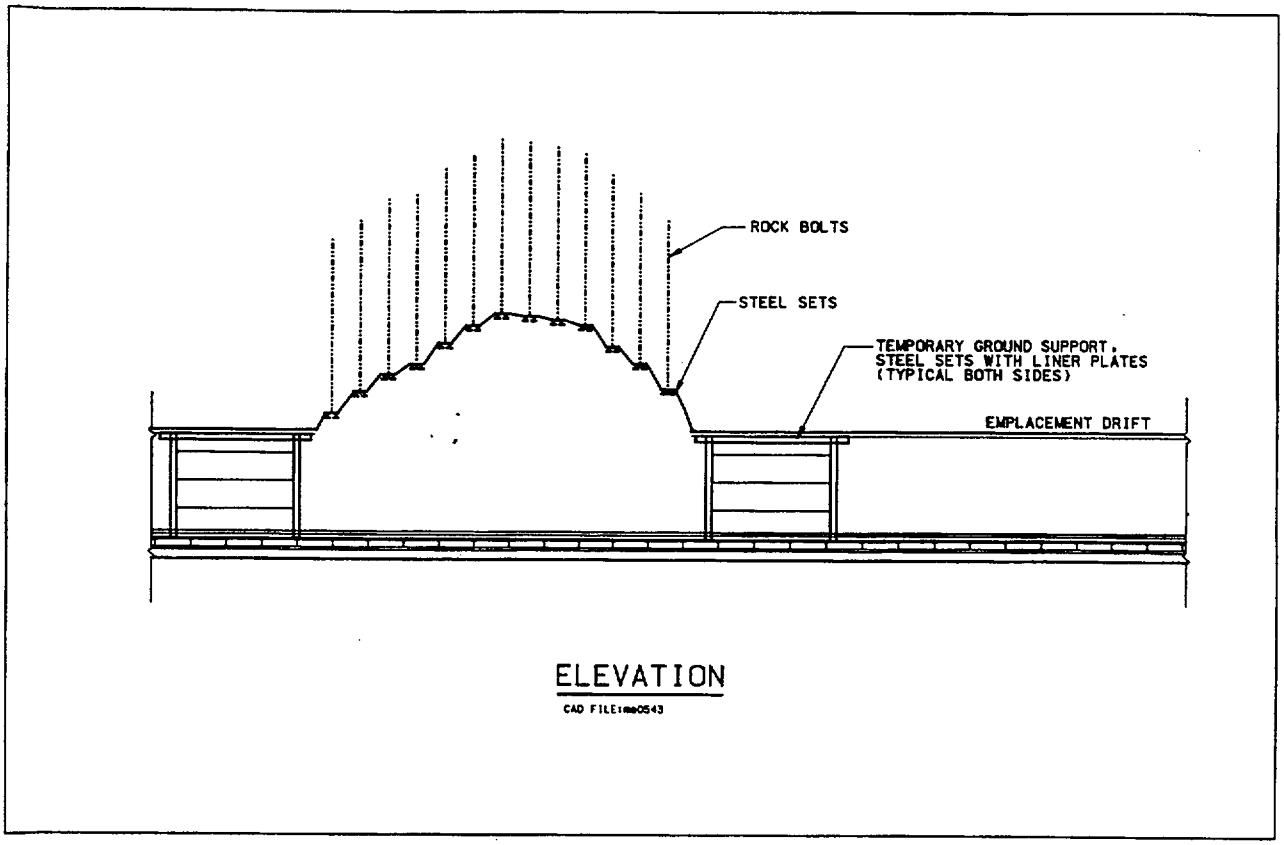


Figure 17. Restored Emplacement Drift

The loaded bed plate could be accessed by the previously placed emplacement gantry from within the emplacement drift. The gantry could be directed to pull the disconnected bed plate to the required position on the expand deck area. This could be accomplished by making a partial lift of the pallet and dragging the WP/pallet assembly and roller-supported bed plate to the proper position. The bed plate rollers facilitate this process by reducing the force required by the gantry to successfully reposition the WP/pallet assembly. After the bed plate is appropriately positioned, the gantry would properly lift the WP/pallet assembly and normal emplacement procedures could be continued.

If the positioning efforts were not successful, the transporter with the exposed WP would be returned to the WHB where the situation would be remedied. Suitable radiation and personnel access control measures would be instituted to ensure that personnel are restricted to areas a safe distance from the exposed WP during transit.

6.2.8 Emplacement Drift Restoration

In addition to normal and abnormal retrieval operations, the WERS shall support restoration activities in the repository. The term "restoration" is used to indicate action taken to remediate an abnormal event involving the WERS (CRWMS M&O 2000f, Section 1). Restoration after an abnormal event may require clearing of failed equipment, rock, and ground support. It will also include the stabilization of the existing ground support and installation of new ground support as required. Changes to the previous VA design, as noted in Section 6.2.1, affect only the emplacement drift; and therefore, this section will focus on the mitigation activities required to restore the emplacement drifts. The mitigation activities to restore the ramp, main drifts, and turnouts have not been affected by design changes due to EDA II or SR.

A performance confirmation gantry (CRWMS M&O 1998a, Section 7.2.5.2), or other suitable surveying equipment, would be used to determine the extent of the infrastructure damage within the emplacement drift. Items to be checked may include the gantry track, the third rail system, ground support system, extent of any rock-fall area, and any differential settlement of the drift invert.

After the removal of the WP/pallet assemblies and the WERS equipment from the affected emplacement drift, work may commence to rebuild the drift ground control, subsurface transport system, and drift invert, as applicable. Much of the damaged equipment and any debris from the abnormal event will have been removed during the retrieval effort, as described in Section 6.2.6. Additional loose material from the rock fall opening may have to be removed with the use of the scaling machine (CRWMS M&O 1998a, Section 7.2.5.14) to stabilize the emplacement drift infrastructure. Further stabilization may require the use of rock bolting (Figure 17).

Tunnel forms (CRWMS M&O 1998a, Section 7.2.5.15) will be used to re-establish ground control conditions. The forms are constructed so that a collapsed set of forms on a rail-mounted carrier can easily pass through a set of previously erected forms and then expanded. Any voids in an emplacement drift that may affect the reliability of the ground control system will have to be evaluated at the time of the occurrence, and most suitable techniques and materials to fill such voids will then have to be considered. The liner system, steel sets, ballast, and other components would be replaced or rebuilt, as required. Due to the fact that all WPs and/or radioactive sources have been removed prior to the start of the restoration effort in the drift, site worker personnel may now access the drift and control this phase for drift restoration.

6.3 RETRIEVAL OF CONTAMINATED WASTE PACKAGES.

The focus of this section is to develop conceptual level strategies for the retrieval and transport of contaminated WPs. This section will include derivation of WP contamination limits, contamination monitoring, contamination control, radioactive conditions and hazard evaluations.

Contamination of WP surfaces may result from normal handling inside of the WHB. Surface contamination may persist even after subsequent decontamination efforts prior to emplacement within the repository. An additional, but unlikely, source of contamination would result from a leaking WP. The types of radionuclides released from a leaking WP would be indistinguishable from those present under normal conditions of surface contamination. There is a possibility that some fraction of the removable contamination on the external surface of each WP could be released to the air of the MGR and be exhausted through the ventilation system following transport and emplacement. If sufficiently large, such a release could present an inhalation hazard to subsurface workers or downwind receptors. While the contamination released from one WP may be insignificant, the accumulated release from a large number of WPs may become significant. It is therefore important to establish limits on WP contamination bearing in mind this cumulative effect.

Low-level, chronic releases from slightly contaminated WPs or potential leaking WPs are not expected to pose a significant health impact to workers or the public. Severe accidents resulting in one or more breached WPs may release larger amounts of radionuclides over shorter periods and may require mitigation measures such as HEPA filtration of the ventilation exhaust. Establishing contamination limits to account for such low-probability accidents is not within the scope of this analysis. However, the same instruments and controls used to monitor routine contamination, as described in Section 6.3.2, may be used to determine the extent of contamination from accident events.

As indicated above, the bases for deriving WP contamination limits are airborne pathways during the pre-closure period. Therefore, contamination limits based on groundwater or any other pathways are outside the scope of this analysis.

6.3.1 Derivation of WP Contamination Limits

The primary purpose of establishing surface contamination limits for WPs is to ensure that the radiation dose to members of the public or occupationally exposed individuals will remain below the applicable limits. Since radiological dose- and concentration-based limits for the protection of the public are much more stringent than the occupational limits, contamination limits derived based on public protection criteria will be also be protective of workers, as discussed in Section 6.3.1.3. A secondary purpose is to limit the results of any spread of secondary contamination to transport equipment and MGR surfaces in an effort to reduce radiation exposure to comply with ALARA project goals. The system shall be designed in accordance with the project program goals for radiation exposure to be as low as is reasonably achievable (Criterion 4.2.24).

It is desirable that the derived limits be measurable by standard nuclear industry methodologies. Such methodologies include the application of wipes to sample the removable contamination on 100 cm^2 areas of the potentially contaminated surface. Table 1 of Nuclear Regulatory Commission (NRC) Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors* (Section 4.3.3), lists surface contamination guidelines that have been used by NRC licensees to demonstrate compliance for purposes of license termination and unrestricted release of contaminated material and property since 1974. These values are the same as those listed in Appendix D of 10 CFR 835. More recently, Table 1 in *Surface and Volume Radioactivity Standards for Clearance* (ANSI/HPS N13.12-1999), lists screening levels for clearance of surface-contaminated materials. These guidelines provide a bounded value against which the proposed limits can be compared. While it is recognized that unrestricted release standards may be overly conservative, it is nonetheless necessary to consider the risk to workers from multiple WPs within the closed environment of subsurface repository. Consequently, the cited guidance and criteria may be appropriate as an initial starting point.

There are two possible approaches to airborne releases from the repository exhaust shafts. One approach is based on limiting the concentrations of airborne effluents at the exhaust shaft; the other is based on limiting the dose to the downwind receptor taking into account dispersion from the exhaust shaft to the receptor location. These approaches may be used to demonstrate regulatory compliance with airborne emission standards during repository licensing and operation. However, in the context of this analysis, these approaches are only used to provide a starting point and a rational basis for deriving WP surface contamination limits.

Column 1 of Table 2 of Appendix B to 10 CFR 20 lists the "radionuclide concentrations which, if inhaled ... continuously over the course of a year, would produce a total effective dose equivalent of 0.05 rem" (50 mrem). This implies that the individual resides continuously at the location of the exhaust, an extremely conservative assumption. Since this approach uses the radionuclide concentration in the exhaust air, the concentration will depend directly on the ventilation flow rate at the exhaust shaft without taking into consideration any differences in deposition, plate-out, or other species-dependent concentration reduction phenomena that may occur.

The target receptor in the second approach is the maximally exposed individual on the surface. This may be either the maximally exposed off-site individual (8,760 hrs/yr exposure) or the maximally exposed non-radworker on-site individual (2,000 hrs/yr exposure). As stated in 40 CFR 61.92 (Subpart H-National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities): "Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr." In this regulation, all applicable pathways (including ingestion of contaminated food and external exposure from plume and deposited radionuclides) must be considered. However, significant amounts of dilution due to air dispersion would occur between the exhaust shaft and any downwind receptor location. This approach is independent of the ventilation flow rate, but depends on the total curies released from the shaft during one year. This approach would likely result in higher allowable WP surface contamination limits as discussed in Section 6.3.1.2. Therefore it will not be used in derivation.

6.3.1.1 Air-Concentration-Based Limits

Assuming that airborne contamination is only due to releases from WP surfaces and not from leaking WPs, a WP surface contamination limit, C_{surf} (Ci/m²), based on the airborne effluent concentration limit, ECL (Ci/m³), may be derived using:

- The surface area of the average WP, A_{WP} (m²)
- The resuspension rate of the surface contamination, RR (/yr)
- The effective release fraction from all emplaced WPs, ERF
- Duration of the release, t (yr)
- The design ventilation flow rate, per exhaust shaft, V (m³/yr)
- The maximum number of WPs emplaced per year, N (/yr)

The airborne ECLs are based on an annual dose limit of 0.05 rem. It is conservative to assume that the resuspension rate for surface contamination is 4×10^{-5} per hour (DOE 1994, p. 4-101) (Assumption 5.3). This is equivalent to a resuspension rate (RR) of 0.35/yr. Since the concentration on the surface decreases over time in proportion to the remaining concentration, a first-order differential equation may be used to represent the process:

$$\frac{dC_{surf}}{dt} = -RR \cdot C_{surf} \qquad \text{(Eq. 1)}$$

The total activity on the WP surface is given by the product of the WP surface area, A_{WP}, and the surface contamination limit, C_{surf}. In terms of the activity release rate, the solution to Equation 1 is:

$$RR\, A_{WP}\, C_{surf}(t) = RR\, A_{WP}\, C_{surf}(0)\, e^{-RR\,t} \qquad \text{(Eq. 2)}$$

The time-integrated effective release fraction, ERF, of contamination from the emplaced WPs is given by:

$$\text{ERF} = \int_{t_1}^{t_2} RR\ e^{-RR\,t}\, dt \qquad \text{(Eq. 3)}$$

The solution to Equation 3 is:

$$\text{ERF}\ (t) = RR\left(-\frac{e^{-RR\,t}}{RR}\right)\Bigg|_{t=t_1}^{t=t_2}$$

$$\text{ERF}\ (t) = RR\left[-\frac{\left(e^{-RR\,t_2} - e^{-RR\,t_1}\right)}{RR}\right]$$

$$\mathrm{ERF}\ (t) = \left(e^{-RR\,t_1} - e^{-RR\,t_2}\right) \quad \text{(Eq. 4)}$$

Using Equation 4, the effective release fraction in the first year (ERF_1, setting $t_1 = 0$ and $t_2 = 1$), with $RR = 0.35/yr$, is:

$$ERF_1 = (1 - e^{-0.35}) = 0.295 \quad \text{(Eq. 5)}$$

The effective release fraction in the second year (ERF_2, setting $t_1 = 1$ and $t_2 = 2$) is:

$$ERF_2 = (e^{-0.35} - e^{-0.35(2)}) = 0.21 \quad \text{(Eq. 6)}$$

Therefore, if the annual number, N, of emplaced WPs is constant over several years T, the total effective release fraction, $ERF(T) = ERF_1 + ERF_2 + \ldots + ERF_T$, is given by:

$$\mathrm{ERF}\ (T) = (1 - e^{-0.35\,T}) \quad \text{(Eq. 7)}$$

After 15 years, the effective release fraction is 0.99. Therefore, it is conservative, but not unrealistic, to set ERF = 1 over the period during which WPs will be emplaced at a relatively constant rate. One can further postulate that any material that is deposited onto drift surfaces is itself resuspended and exhausted during one year (Assumption 5.4). Therefore, the average annual concentration at the exhaust, C_{air} (Ci/m³), would be calculated as:

$$C_{air} = \frac{C_{surf} \times A_{WP} \times [N \times t]}{V \times t} \quad \text{(Eq. 8)}$$

Setting the exhaust concentration, C_{air}, to the effluent concentration limit, ECL, and solving for the WP surface contamination limit, C_{surf}, yields the following:

$$C_{surf} = \frac{\mathrm{ECL} \times V}{A_{WP} \times N} \quad \text{(Eq. 9)}$$

The limits derived using Equation 9 assume that all WPs will be contaminated at the applicable limit, resulting in an average air concentration that meets the effluent release limit. In practice, not all WPs will be contaminated to the limit, and any WP that exceeds the surface contamination limits will require decontamination. Therefore, another factor of conservatism is introduced into Equation 9.

The total surface area of each WP is given by:

$$A_{WP} = 2\pi R^2 + 2\pi RL \quad \text{(Eq. 10)}$$

where:

R = WP radius, m
L = WP length, m

A single WP design will not be able to accommodate the different types of spent nuclear fuel or high-level waste. Table 1 lists the dimensions of different WP categories and the calculated surface area for each category is presented in Table 3. In addition, Table 3 provides the projected total numbers of each WP category under two different scenarios. The last row in Table 3 lists the unweighted average WP area as well as the average WP area weighted by the number of WPs in each category. A weighted-average WP area of 31.3 m² is used in the establishing the surface contamination limits (Section 4.1.6 and Assumption 5.3).

Table 3. WP Surface Area Calculation

	Nominal WP Dimensions			Design Inventory		Full Inventory	
WP Design	Length (m)	Dia. (m)	Area (m^2)	Number	Area (m^2)	Number	Area (m^2)
21 PWR AP/CR	5.17	1.64	30.9	5810	179307	4600	141964
44 BWR AP	5.17	1.67	31.5	3750	118144	3000	94515
5 DHLW/DOE SNF Short	3.59	2.11	30.8	1410	43415	1100	33870
Naval SNF Long	6.07	1.95	43.2	170	7337	100	4316
Total	n/a	n/a	n/a	11140	348202	8800	274665
Average Area per WP (m^2)	n/a	n/a	34.1	n/a	31.3	n/a	31.2

6.3.1.1.1 Example Using Co-60

A possible contaminant on a WP surface is Co-60, which is the dominant component of the activated corrosion products on the surfaces of spent fuel assemblies. Therefore, an example using Co-60 will illustrate the methodology that can be extended to all other radionuclides of concern.

The parameters used to calculate C_{surf} are:

ECL (Co-60, Class Y) = 5×10^{-11} μCi/ml = 5×10^{-11} Ci/m³
where 1 μCi/ml = 1 Ci/m³ (Source: 10 CFR 20 App. B, Table 2, Column 1)
A_{WP} = 31.3 m² (Section 4.1.4).
N = 605 WPs (Assumption 5.2).
V = 800 m³/s = 2.52×10^{10} m³/yr, (Assumption 5.5)

Inserting the above values into Equation 9 results in (in disintegrations per minute (dpm)):

$$C_{surf}(\text{Co-60}) = \frac{5\times10^{-11}\times 2.52\times10^{10}}{31.3\times605}$$

$$= 6.7\times10^{-5}\ \text{Ci/m}^2 = 67\ \mu\text{Ci/m}^2 = 1.5\times10^{6}\ \text{dpm}/100\ \text{cm}^2$$

The limit derived for Co-60 is 1,500 times higher than the removable contamination value listed in Table 1 of *Termination of Operating Licenses for Nuclear Reactors* (Regulatory Guide 1.86) (used for unrestricted releases of contaminated material and equipment) for beta/gamma emitters and would be very easily measured if taken by a standard wipe. It is 250 times higher than the surface screening values in Table 1 of *Surface and Volume Radioactivity Standards for Clearance* (ANSI/HPS N13.12-1999) for Group 2 radionuclides (including Co-60). Therefore, in this example, demonstration of compliance can be achieved.

6.3.1.1.2 Example Application for Other Radionuclides

The above calculation can be performed for all other radionuclides of concern by simply replacing the ECL for Co-60 with the appropriate ECL from 10 CFR 20, App. B. Table 4 lists the WP surface contamination limits derived for radionuclides that may contribute over 99 percent of the inhalation dose following an accidental release (CRWMS M&O 1998b, p. 26), but the table can be extended to any other radionuclide of concern that may be present on the WP surface. Gaseous radionuclides such as tritium (as tritiated water vapor) and Kr-85 are excluded from the table because they would not be present as removable surface contamination on a WP.

Table 4. Derived WP Surface Contamination Limits

Radionuclide	10 CFR 20 ECL µCi/ml	Derived WP Limits		NRC Regulatory Guide 1.86 dpm/100 cm²	ANSI/HPS N13.12-1999 dpm/100 cm²
		Ci/m²	dpm/100 cm²		
Co-60	5×10^{-11}	6.7×10^{-5}	1.5×10^{6}	1.0×10^{3}	6.0×10^{3}
Sr-90	6×10^{-12}	8.0×10^{-6}	1.8×10^{5}	2.0×10^{2}	6.0×10^{3}
Cs-137	2×10^{-10}	2.7×10^{-4}	5.9×10^{6}	1.0×10^{3}	6.0×10^{3}
Pu-238	2×10^{-14}	2.7×10^{-8}	5.9×10^{2}	2.0×10^{1}	6.0×10^{2}
Pu-239	2×10^{-14}	2.7×10^{-8}	5.9×10^{2}	2.0×10^{1}	6.0×10^{2}
Pu-240	2×10^{-14}	2.7×10^{-8}	5.9×10^{2}	2.0×10^{1}	6.0×10^{2}
Pu-241	8×10^{-13}	1.1×10^{-6}	2.4×10^{4}	2.0×10^{1}	6.0×10^{4}
Am-241	2×10^{-14}	2.7×10^{-8}	5.9×10^{2}	2.0×10^{1}	6.0×10^{2}
Cm-244	3×10^{-14}	4.0×10^{-8}	8.9×10^{2}	2.0×10^{1}	6.0×10^{2}

For all radionuclides in Table 4, except Pu-241, the derived WP surface contamination limits are higher than the limits in Table 1 of NRC Regulatory Guide 1.86 (Section 4.3.3) and Table 1 of ANSI/HPS N13.12-1999 (Section 4.3.1). Pu-241 is a transuranic beta-emitter that decays to Am-241, an alpha emitter. The derived WP limit for Pu-241 (24,000 dpm/100 cm²) is higher than the value for removable contamination of 20 dpm/100 cm² listed in Table 1 of NRC Regulatory Guide 1.86, less than half of the surface screening level of 60,000 dpm/100 cm² listed in Table 1 of ANSI/HPS N13.12-1999. However, Pu-241 will not be found separately from the alpha-emitting plutonium isotopes (i.e., Pu-239, Pu-239 and Pu-240). The surface contamination limits for the latter will indirectly restrict the concentration of Pu-241 to less than the derived limit.

In applying the limits to the concentrations of individual isotopes, the sum-of-fractions rule applies. However, for ease in demonstrating compliance, it may be necessary to derive surface contamination numbers that are easily/quickly measured (e.g., gross beta-gamma, gross alpha). The simplest and most conservative approach consists of selecting the most restrictive alpha or beta-gamma contamination limit from the list of individual radionuclides. Based on the values reported in Table 4, the most restrictive gross beta-gamma and gross alpha values would be 180,000 (excluding Pu-241 for reasons discussed above) and 590 dpm/100 cm², respectively.

6.3.1.2 Dose-Based Limits

The alternative use of the 40 CFR 61.92 dose-based limit (10 mrem/yr at the receptor location) would most likely result in higher WP surface contamination limits. This is due to the significant amount of dispersion/dilution that would occur between the exhaust shaft and the hypothetical receptor. The dose-based approach could be used, if required, when more detailed information becomes available.

6.3.1.3 Consideration of Worker Dose

The limits calculated in Table 4 would be protective of subsurface workers. As mentioned earlier, the 10 CFR 20, Appendix. B, effluent limits are based on an individual receiving 0.05 rem (50 mrem) from inhaling the effluent concentration continuously during one year. These effluent concentration limits were derived in 10 CFR 20, Appendix B, Table 2, Column 1, based on a 300-fold reduction of the derived air concentrations (DACs) that apply to occupational exposures. A subsurface worker may be expected to work 2,000 hours/year, and would not always be exposed to the concentration in the exhaust main, unless performing maintenance in the exhaust main during the entire work year. In the latter extreme example, the annual inhalation dose to a worker from the release of WP surface contamination would not exceed 0.01 rem (10 mrem). Per 10 CFR 20, Appendix B, this reduction was calculated using a factor of 3 to adjust for the difference in exposure time and the inhalation rate for a worker and that for members of the public; and a factor of 2 to adjust the occupational values (derived for adults) from those applicable to other age groups. A dose of 10 mrem/yr is 500 times lower than the occupational dose limit (5 rem/yr). Therefore, there is no anticipated need for respiratory protective equipment for subsurface workers under normal operating conditions.

6.3.2 Contamination Monitoring

Monitoring of surface and airborne contamination provides assurance that annual doses to workers and members of the public remain within their respective limits. There are several potential sources of contamination that may require monitoring.

The primary sources of contamination are the contents of the WP itself. Table 4 lists some radionuclides that would present an inhalation hazard during an accidental release. Of these, only Co-60 is present as the activated corrosion products on the surfaces of spent fuel assemblies and is a potential residual contaminant. All others are mixed fission products and transuranics that would only be released from SNF assemblies whose cladding had failed.

Not all of the contamination on the external surfaces of a welded WP may have been removed. This presents a potential source of secondary contamination, affecting the WP transport and emplacement equipment through direct contact. Air in the drifts may also become contaminated from airborne releases from contaminated surfaces of the WP. Contamination from WPs may also be transferred to equipment surfaces through airborne releases and subsequent deposition.

The regulatory requirements for conducting surveys and monitoring contamination levels and doses are described in the following section. These are followed by the recommended strategies to assure compliance with the regulations and allow timely detection of abnormal levels of contamination.

6.3.2.1 Regulatory Requirements

The following excerpts taken from 10 CFR 20 and 10 CFR 835 are relevant to the issue of contamination surveys and monitoring.

10 CFR 20.1501, *General*, requires that:
(a) Each licensee shall make or cause to be made, surveys that—
  (1) May be necessary for the licensee to comply with the regulations in this part; and
  (2) Are reasonable under the circumstances to evaluate—
    (i) The magnitude and extent of radiation levels; and
    (ii) Concentrations or quantities of radioactive material; and
    (iii) The potential radiological hazards.

10 CFR 20.1502, *Conditions requiring individual monitoring of external and internal occupational dose*, requires that:
(b) Each licensee shall monitor (see Sec. 20.1204) the occupational intake of radioactive material by and assess the committed effective dose equivalent to—
  (1) Adults likely to receive, in 1 year, an intake in excess of 10 percent of the applicable Annual Limit on Intake (ALIs) in table 1, columns 1 and 2, of appendix B to Secs. 20.1001-20.2402;
  (2) Minors likely to receive, in 1 year, a committed effective dose equivalent in excess of 0.1 rem (1 mSv); and
  (3) Declared pregnant women likely to receive, during the entire pregnancy, a committed effective dose equivalent in excess of 0.1 rem (1 mSv).

10 CFR 20.1701, *Use of process or other engineering controls*, requires that:
The licensee shall use, to the extent practical, process or other engineering controls (e.g., containment or ventilation) to control the concentrations of radioactive material in air.

10 CFR 835.403, *Air monitoring*, requires that:
(a) Monitoring of airborne radioactivity shall be performed:
  (1) Where an individual is likely to receive an exposure of 40 or more DAC-hours in a year; or
  (2) As necessary, to characterize the airborne radioactivity hazards where respiratory protective devices for protection against airborne radionuclides have been prescribed.
(b) Real-time air monitoring shall be performed as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material.

These regulations specify the legal limits for radiation exposure and the conditions under which radiation protection programs must be implemented. 10 CFR 835 and 10 CFR 20 form the basis for the protection and monitoring methodologies presented in this section. Requirements contained in 10 CFR 835 are presented for comparison with similar requirements in 10 CFR 20. However, since adherence to the regulatory requirements of 10 CFR 20 will be required for licensing repository operations, any conflicts between the requirements of 10 CFR 20 and 10 CFR 835 will be resolved in favor of the requirements in 10 CFR 20.

6.3.2.2 Monitoring Strategy

An effective monitoring strategy will require that sources of potential contamination be monitored at those points where corrective action can be taken to prevent further spread of contamination. This implies that monitoring should be conducted at the points of primary, secondary or even tertiary contamination. The greatest efficiency will be obtained by focusing on locations and times where the contamination potential is highest. Such strategy must also take into account the selection of appropriate monitoring instruments and techniques. At a minimum, six monitoring points should be considered:

- WP surfaces prior to WP loading onto transporter
- Air inside loaded transporter during WP transport from surface to emplacement drift
- Transporter surfaces following WP emplacement
- Emplacement gantry surfaces at time of gantry transfer between emplacement drifts
- Air in emplacement drift ventilation raises (upstream of exhaust main)
- Air at surface exhaust shaft(s)

In addition to demonstrating compliance, monitoring can be useful in establishing trends and uncovering deviations from trends. This allows appropriate action to be taken before the contamination limits are actually approached or exceeded. Establishing the monitoring program prior to emplacement operations to determine background radiation and contamination levels is also essential; this allows contamination originating from the WPs to be distinguished from background levels.

Compliance with surface contamination limits can be demonstrated by taking surface wipes or "smears" over a fixed area and measuring the contamination level (either isotopically or gross beta/gross alpha). Frisker devices, such as pancake detectors, may also be used to detect total surface contamination in areas where the radiation background is sufficiently low. Compliance with airborne contamination limits is demonstrated by continuous or periodic (grab sample) monitoring of radioactive particulates in air. The background contributions of naturally occurring radon progeny in air and deposition on surfaces must be considered when establishing the required sensitivity of the instrument or measurement methodology. The type of radiation to be measured and the applicable contamination limit must be considered when selecting the appropriate instrument or measurement methodology.

The primary source of contamination, the WP surfaces, should be surveyed following decontamination of each loaded and welded WP, but prior to loading the WP onto the transporter. Due to the high radiation background in the vicinity of a loaded WP, such wipes would have to be taken remotely and analyzed at a location with lower background radiation levels.

The air in a transporter containing a WP could become contaminated during the transport from the surface facility to the emplacement drift. Locating the inlet tube for an air sampler inside the transporter, but placing the mechanical and electronic components outside the transporter, would allow the maximum airborne contamination levels to be monitored. Once this air is released to the main drift by leaking from the transporter or after opening the transporter doors, the concentration will drop rapidly due to dilution with the ventilation air. High levels of airborne contamination inside the transporter may be indicative of a leaking WP or ineffective WP decontamination and/or monitoring at the surface. Early detection allows the WP to be returned to the surface for further treatment and reduces the spread of contamination.

The transporter and emplacement/inspection gantry may become contaminated directly after coming into contact with the contaminated surfaces of a WP/pallet assembly. The former may also become contaminated from deposited airborne contamination originating from the latter. The most appropriate time to monitor for such contamination is prior to returning the empty transporter to the surface or after removal of the emplacement/inspection gantry from the emplacement drift. The most appropriate locations for surveys are surfaces that may have come into contact with the WP/pallet assembly (e.g., lifting arms) or contaminated surfaces in the emplacement drift (e.g., gantry wheels). Surface contamination in excess of allowable limits, or even established trends, may be indicative of a leaking WP or ineffective WP decontamination and/or monitoring at the surface. In the case of a contaminated transporter, the recently emplaced WP may be retrieved and returned to the surface for further treatment. In the case of a contaminated emplacement/inspection gantry, it may only be possible to identify the emplacement drift containing the WP which contributed to the contamination, and all WPs in that drift would have to be considered suspect and removed.

The WP surface contamination limits derived in Section 6.3.1 are based on inhalation doses to subsurface workers that would not exceed 10 mrem/yr. A DAC is defined as the air concentration of a radionuclide that would result in a Committed Effective Dose Equivalent of 5 rem/yr, and an ALI corresponds to an intake that would result in this Committed Effective Dose Equivalent. Thus, a 10 mrem/yr Committed Effective Dose Equivalent corresponds to $1/500^{th}$ of an ALI and corresponds to 4 DAC-hours in a year. Therefore, no airborne monitoring is required to demonstrate compliance with the regulations under normal operating conditions. However, exhaust shaft monitors may be installed to verify that average annual effluent concentrations are within 10 CFR 20, Appendix B, Table 2, Column 1, limits. Air monitors may also be installed in each drift ventilation raise to detect any significant releases of radionuclides that may result from a WP leak. This strategy will increase the probability of detecting a significant leak and help identify the particular emplacement drift containing the leaking WP.

6.3.3 Evaluation of Radiological Conditions and Potential Hazards

The purpose of contamination monitoring is to establish normal conditions as well as to assure that abnormal contamination levels do not go undetected. If surface or airborne contamination levels in excess of trends or allowable limits are detected on the WP, equipment, and/or drifts, then the radiological conditions and potential hazards and mitigation procedures will require evaluation on a case-by-case basis.

Potential hazards from abnormal levels of surface and airborne contamination include internal radiological exposure to workers due to incidental ingestion of removable surface contamination and inhalation of contaminated air, unless precautions are undertaken by workers. Such precautions may include the use of respirators, anti-contamination clothing, modifications to airflow, and containment strategies to limit the spread of contamination. External radiation hazards exist in the vicinity of unshielded WPs; such hazards are reduced by the use of time, distance and shielding. However, external radiation is not expected to be a significant hazard, relative to internal exposure, from most airborne or deposited radionuclides. Appropriate worker protection strategies are addressed in Sections 6.3.4 and 6.3.5.

High surface contamination levels on the WP detected prior to loading the WP onto the transporter are a possible indication that surface decontamination may not have been accomplished to the required levels. This condition does not pose an immediate hazard to workers, but requires action to reduce surface contamination levels so that the contamination is not spread to the transporter and other areas of the MGR.

Detection of air contamination in excess of the trend inside a loaded transporter may be an indication of a leaking WP or of high levels of WP surface contamination. In either case, the transporter and WP should be returned to the surface facility to determine the source of the contamination and to provide the appropriate remedial action. Some of the airborne contamination may leak outside the transporter; however, due to the significant dilution afforded by the main drift airflow, it is unlikely that personnel will require the use of protective respiratory equipment. Excess airborne contamination inside the transporter could result in elevated contamination levels on the transporter surfaces due to deposition. Therefore, such surfaces should be surveyed for removable contamination after the WP has been unloaded. If excessive levels of surface contamination are detected, the transporter should be decontaminated prior to re-use.

Detection of high levels of surface contamination on the transporter surfaces after emplacement of a WP may also be an indication of a leaking WP or of high levels of WP surface contamination. The recently emplaced WP should be retrieved and placed back into the transporter and returned to the surface facility to determine the source of the contamination and to provide the appropriate remedial action. It is also possible that the emplacement gantry became contaminated during the transfer of the WP from and to the transporter. Therefore, the emplacement gantry should also be removed from the emplacement drift, surveyed, and released or decontaminated, depending on the survey results. High contamination levels on all surfaces of the gantry, not just those surfaces in contact with the pallet, could indicate that the entire emplacement drift may be contaminated, possibly due to a leaking WP. This may require removal of all WPs in that drift, followed by surveys of the drift surfaces to determine if the emplacement drift requires decontamination.

Contamination surveys of the emplacement or inspection gantry may find high levels of surface contamination during its transfer to another emplacement drift. In this case, all WPs contained in the emplacement drift from which the gantry was removed would be suspect and may have to be retrieved. As indicated above, once all WPs have been removed, surveys of the drift surfaces should be conducted to determine if the emplacement drift requires decontamination.

High levels of air concentrations, as measured by the emplacement drift ventilation raise air monitor, may also be indicative of a leaking WP or of excessive WP surface contamination. It may also be indicative of contamination that has spread to significant portions of the affected emplacement drift and to other WPs inside that drift. Detection of abnormal levels may require that the emplacement or inspection gantry (if one is present) and all WPs in that drift be retrieved and returned to the surface facility to determine the source of the contamination and to provide the appropriate remedial action.

Unusual increases in concentrations, as measured in the exhaust shaft monitor, even if not in excess of allowable limits, may also be indicative of a problem. However, it is more likely that the exhaust shaft air monitor would serve primarily as means to ensure compliance with regulations governing off-site releases of airborne radionuclides. The effluent concentrations at the exhaust shaft would be lower than the concentrations at the emplacement drift exhaust due to the dilution from other sources in the repository.

6.3.4 Contamination Control during WP Retrieval and Transport

Two principal strategies may be used to control the movement of contamination during WP retrieval and transport. These strategies may be used independently or simultaneously as warranted by the particular situation.

The first strategy is to contain, to the extent possible, the further spread of contamination to uncontaminated areas This is most readily accomplished by the use of physical barriers between the contaminated and uncontaminated areas. HEPA filter bulkheads would be used to contain contamination generated during an abnormal event. Bulkheads could be installed upwind and downwind from the abnormal event to isolate the contamination site from continued operations and to maintain worker safety (CRWMS M&O 1998a, Section 7.2.5.1). The second strategy is to control the flow of ventilation from areas of lower contamination to areas of higher contamination. This is most readily accomplished by placing an auxiliary ventilation intake near the source of contamination and directing the flow of air through a high efficiency particulate air (HEPA) filter. The ventilation flow rate must be sufficiently high to overcome the prevailing flow of air through the contaminated area. This can be accomplished by the use of the mobile filtration units consisting of a HEPA filter, a plenum, and one or more fans (CRWMS M&O 1998a, Section 7.2.5.1).

In the case of a transporter in which high airborne concentrations have been detected, the appropriate containment strategy would be to seal any openings through which air may leak (e.g., transporter shield doors). This should be accomplished prior to moving the transporter back to the surface. A reduction in the contamination levels may be accomplished by drawing air inside the transporter through a HEPA-filtered intake, which would have the additional benefit of creating a negative-pressure air space inside the transporter relative to the outside air.

During retrieval of one or more suspect WPs, accessible surfaces of the WP will be covered with a heat-resistant, nonpermeable material to reduce the spread of contamination during transport. This pouch will be remotely installed by equipment installed on the multipurpose hauler (CRWMS M&O 1998a, Section 7.2.5.12). In addition, a temporary heat-resistant liner or sleeve placed inside the transporter prior to loading the WP may further serve to reduce the spread of contamination (Criterion 4.2.16). If more than one WP is suspect, this procedure may have to be applied to all WPs inside a drift.

It is possible that transporter or gantry surfaces may become contaminated as a result of the retrieval operations. To reduce the spread of contamination from transporter or gantry surfaces, these surfaces should be decontaminated to the extent possible by using a HEPA-filtered vacuum cleaner or other appropriate method. The WERS equipment shall have an appropriate surface finish and geometry to facilitate decontamination and limit the accumulation of fixed contamination (Criterion 4.2.27). Cleanup of contaminated drift surfaces may require additional control measures, such as the use of ventilation control that reduce the airflow in the affected emplacement drift and re-route most of the air to an auxiliary ventilation intake. Temporary barriers placed around the contaminated areas may also be required. The WERS shall be designed to decontaminate opening below the levels given in Section 222 of "U.S. Department of Energy Radiological Control Manual" or apply a fixative coating over contaminated surfaces to prevent the spread of contamination (Criterion 4.2.26).

6.3.5 Equipment and Retrieval Strategy

As soon as contamination above specified limits (e.g., as derived in Section 6.3.1) is identified, or if monitoring indicates unusual levels of contamination, the previously emplaced WP(s) may need to be retrieved for inspection and possible decontamination. The strategy for retrieval of a potentially contaminated WP will likely consist of the following activities:

- Evacuate subsurface personnel not directly involved in transporter operation (emplacement side only).
- Ensure transport personnel are wearing air filtration respirators and appropriate protective clothing.
- Retrieve the potentially contaminated WP/pallet assembly using a reversal of the normal emplacement process and bring it to a specially prepared decontamination room at the surface.
- Remove emplacement/retrieval gantry from emplacement drift and bring it to the subsurface decontamination alcove.
- Observe methods of contamination control outlined in Section 6.3.4.

Following the retrieval of a contaminated WP, it will be necessary to perform a radiological survey on all interior and exterior surfaces of the transport equipment, e.g., WP transporter, gantry, multipurpose vehicle, multipurpose hauler, and/or gantry carrier). In addition, surveys of the main drift, turnout, and all pathways followed by the returning equipment, such as WP transporter, gantry, and gantry carrier, must be performed. Contaminated equipment and areas will be decontaminated until regulatory requirements are met and further cleaned in accordance with current repository ALARA policies.

A contamination survey of the emplacement drift might be needed as well. For an emplacement drift, the survey would be performed by the remotely controlled performance confirmation gantry (CRWMS M&O 1998a, Section 7.2.5.2). If unacceptable levels of contamination are found, the performance confirmation gantry would have to be removed from the subsurface repository using the same procedure as for the emplacement/retrieval gantry. A decision would then have to be made whether to remove all WPs in that drift and decontaminate. The packages would be removed using the steps outlined above.

Retrieval of a contaminated WP includes the use of standard radiation detection. In addition, a WP transporter, an emplacement/retrieval gantry, and a gantry carrier will be required. Prior to transport of the WP to the surface, a specially designed, heat resistant, non-permeable pouch would need to be installed prior to retrieval in order to limit radionuclide release as discussed in Section 6.3.4. If no other abnormal conditions except the high level of contamination exist, the WP retrieval would proceed using the retrieval procedures as described in Section 6.1. Emphasis would be placed on WERS equipment decontamination per Section 6.3.3.

If an abnormal event occurs in tandem with WP contamination (or breach), the procedures outlined above are still valid. The contamination control procedure developed in Section 6.3.4 to prevent contamination spread becomes a very important part of an abnormal retrieval operation as described in Section 6.2. All WERS equipment used for retrieval will have to be surveyed and decontaminated after use. Also, it would be necessary to perform a contamination survey of all structures, systems, or components involved with the mitigation.

Note that the retrieval of a breached WP would follow the same procedure as that of a contaminated WP. A WP breach, however, has a higher likelihood of releasing gaseous, as opposed to particulate, contamination into the subsurface area. Because of this, there is a greater reason to expediently transfer the WP into the pouch-equipped transporter. Methods used to determine whether a WP is breached or has surface contamination are beyond the scope of this work.

7. CONCLUSIONS

7.1 GENERAL

This work supports the MGR design that will be presented as part of the SR. This analysis demonstrates that any or all of the WPs in the repository can be relocated within the repository or retrieved from the emplacement drifts and transported to the surface.

Since the issuing of the initial *Retrieval Equipment and Strategy* analysis, several significant changes have been made to the emplacement concept, with resulting changes to the design criteria. As discussed in Section 1, the most notable changes are in response to the EDA II effort and the resulting SR design for the emplacement concept. The EDA II changes include invert design modifications, WP spacing, and an increased source-term dose rate. The latest SR emplacement concept, as presented in the *Bottom/Side Lift Gantry Conceptual Design* (CRWMS M&O 2000a), includes changes to the equipment that handle and emplace WPs. The WPs are handled and stored on dedicated pallets and are collectively known as WP/pallet assemblies.

In general, there will be no significant effect on the waste handling operations and the normal retrieval concept. Normal waste retrieval operations will be the reverse of the waste emplacement operations. Therefore, the basic operations for normal retrieval remain unaffected by these changes.

In the context of EDA II and SR design changes, the primary difference between the previous retrieval analysis and this retrieval analysis are design enhancements to the emplacement drift layout, the mobile equipment, and the materials of construction within the drift. Fundamental changes to the repository design are identified below:

- The shape and orientation of most emplacement drift turnouts has been revised, however, the basic emplacement drift configuration remains unchanged.
- Each WP will now be transported and emplaced on a dedicated emplacement pallet. Therefore, the need for pre-installed WP supports has been eliminated.
- The base material of construction in the emplacement drifts has changed from concrete to steel with granular ballast as a fill material.
- The WP transporter has been reconfigured to provide for simplified, more reliable loading and unloading functions.
- The Emplacement Gantry, also known as the Bottom/Side Lift Gantry (see Sections 4.1.3 and 6.1.2.4), has been redesigned to emplace and retrieve the new WP/pallet assembly. However, the previous design option for WP carry-over is no longer applicable with the current design.

In general, it can be concluded that the EDA II and SR changes that may affect specific WERS equipment items are not significant. Making appropriate provisions for the retrieval operations can readily accommodate these concept changes.

- The WERS equipment is capable of emplacing and retrieving WPs under normal conditions of repository operations (Section 6.1). The revisions to the emplacement drift gantry and the WP transporter, combined with a physical change to the emplacement drift transfer dock, have solved an alignment issue between the WP transporter and the transfer dock during the transfer of a WP/pallet assembly from the transporter to the emplacement gantry. The change to the emplacement drift invert from concrete to steel has no effect on the operation of the gantry during normal conditions.

- The WERS equipment remains capable of retrieving WPs under abnormal conditions (Section 6.2). The change of the emplacement drift invert material has little effect on the retrieval of a derailed emplacement gantry. The specialized retrieval equipment, the emplacement drift gantry carrier, and the multipurpose hauler developed for this mitigation will be able to perform as designed. The equipment previously developed will also perform as designed for restoration of the emplacement drift after a failure of the ground control system.

- The WERS equipment is capable of retrieving and transporting contaminated WPs (Section 6.3). The WP derived contamination limits indicate that compliance with the regulatory guidelines can be accomplished. Evaluation of the conceptual radiological conditions and hazards led to a preliminary monitoring strategy that indicated that the WERS equipment, as originally developed in *Retrieval Equipment and Strategy* (CRWMS M&O 1998a) and modified within this analysis, would be able to mitigate abnormal events appropriately. The WP surface contamination limits were established for the safety of the public, the workers, and to prevent spread of contamination throughout the MGR. This is necessary to reduce radiation exposure and to comply with ALARA project goals.

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Although the findings of this analysis are accurate for the inputs and the assumptions made, further refinements of this analysis are needed for subsequent use as the baseline design evolves in an effort to reduce uncertainties related to the WERS. The results of this analysis are based, in part, on inputs consisting of TBV and TBD data. The inputs that require further confirmation and their related effect on the conclusions of this analysis are as following:

- The minimum and maximum values for WP diameter, length, and loaded weight have a direct effect on the conceptual design of the retrieval equipment (Section 4.1.1).

- The design of the WP pallet, including overall dimensions, material of construction and weight has a direct effect on the conceptual design of the retrieval equipment (Section 4.1.2).

- The size of the debris that the retrieval equipment must segment and remove from the underground has a direct effect on the conceptual design and operation of the retrieval equipment (Criterion 4.2.1 and 4.2.2).

- The radiation environment that the components of the retrieval equipment must withstand and operate within has a direct effect on the design of the retrieval equipment (Criterion 4.2.6).

- The lower subsurface ambient subsurface temperature has little effect on the design and operation of the retrieval equipment (Criterion 4.2.7).

- The exact storage location of the retrieved waste packages has no effect on the conceptual operation of the rail-based retrieval equipment (Criterion 4.2.12).

- The project ALARA goals affect the use of shielding for some manual and off-normal operations. However, for this conceptual design, the specific ALARA goals have no effect on the conceptual operation of the retrieval equipment (Criterion 4.2.24).

- The level to which the system must decontaminate the underground has no effect on the conceptual operation of the retrieval equipment (Criterion 4.2.26).

- The capability of the WERS system to transport and emplace WPs at a rate of 605 WPs per year (Criteria 4.2.3 and Assumption 5.2) has little effect on the conclusions of this analysis. The calculations presented in Section 6.3.1.1 have low sensitivity to the emplacement rate.

According to *Waste Emplacement/Retrieval System Description Document* (CRWMS M&O 2000f, Section 1), the term "recovery" is used to indicate selective removal of a small set of WPs from the underground. The term "retrieval" is used to indicate removal of groups of WPs or the entire inventory of WPs from underground. Semantically, there is a difference between retrieval and recovery. However, this analysis used the term retrieval to address both retrieval and recovery under normal, abnormal, and/or contaminated conditions.

7.2 RECOMMENDATIONS

This analysis has been prepared using preliminary design data for the emplacement drift, the emplacement drift gantry, and the WP transporter. If the final design for these items changes, then some of the observations and conclusion drawn in this analysis will need to be revisited. Much of the design for the WERS system equipment, as presented, is conceptual. However, the technology to develop the WERS equipment currently exists and has been proven in other industries. Many of the components required in the design of this equipment are "off-the-shelf" technology that is currently and readily available. Therefore, this equipment is based on current technology and could be built and employed today, if required.

Based on this analysis, the following modifications and/or design enhancements are suggested in order to support and improve waste retrieval operations. An air-sampling and HEPA filter ventilation system should be designed into the WP transporter design to provide a means of detecting any contamination and isolating it to the interior of the transporter. As discussed in Section 6.2.4 and required by Criterion 4.2.16, the use of an on-board ventilation system to provide a negative pressure within the WP transporter would facilitate the transportation of a contaminated WP to the surface facilities.

Section 6.6.1 of *Bottom/Side Lift Gantry Conceptual Design* (CRWMS M&O 2000a) discusses the electrical power sources envisioned for the gantry. The third rail and a battery backup are the two sources discussed. To facilitate the mitigation of abnormal retrieval operations, an external electrical connection should be an additional option so that an umbilical cord could be attached to the gantry, as described in Section 6.2.4. This option could provide the gantry with electrical power should the third rail within the emplacement drift become damaged or otherwise inoperable.

7.3 FUTURE RETRIEVAL CAPABILITIES

Retrieval criteria state that portions of the system supporting retrieval and restoration shall have an operational life of 135 years and include provisions that support a deferral of closure for up to 300 years after initiation of the waste emplacement (Criterion 4.2.8 and 4.2.9). The conceptual level design of the retrieval equipment provides little opportunity to "include provisions that support a deferral of closure" for such an extended time period. In reality, providing 300 years of capability is much more of an inspection, testing, and extended maintenance issue than a design issue. Maintaining an extended capability would require a substantial, on-going equipment maintenance program, including periodic replacement of time-sensitive parts, such as seals, hydraulic systems, lubricants, etc. Any decision to defer closure for such an extended time would require significant planning and procedures for effective WERS fleet management and equipment replacement to provide the desired capacities.

7.4 CRITERIA COMPARISON

This section determines to what extent the proposed retrieval equipment and strategy meets each of the criteria listed in Section 4.2. Those criteria were derived from the *Waste Emplacement/Retrieval System Description Document* (CRWMS M&O 2000f, Section 1.2).

Section 4.2 does not list all of the criteria set forth in the *Waste Emplacement/Retrieval System Description Document* (CRWMS M&O 2000f, Section 1.2). Criteria not included in Section 4.2 were those deemed not applicable to the conceptual development of the retrieval equipment and strategy. The following provides a brief summary of the criteria, as applicable:

7.4.1 Criterion 4.2.1 (CRWMS M&O 2000f, Section 1.2.1.12) This criterion requires that the WERS have the ability to segment debris from fail ground support material, rock, etc., into pieces. As discussed in Sections 6.2.4 and 6.2.6, the multipurpose vehicle can be fitted with various individual attachments that can perform specific operations. Such attachments include, but are not limited to, a bucket attachment for removing debris, an impact hammer for reducing debris size, demolition shears for cutting steel or other tough material, or a cutting torch to dismantle damaged equipment or structures. Based the conceptual design of this equipment, this criterion has been met.

7.4.2 Criterion 4.2.2 (CRWMS M&O 2000f, Section 1.2.1.13) This criterion requires that the system have the capability to remove debris from the underground. As discussed in Section 6.2.6, a muck container can be installed on the multipurpose vehicle for the removal of rock fall material within an emplacement drift. Installation of the muck container would reduce vehicle travel in and out of the emplacement drift. Normal mining equipment and vehicles would be used to transport the muck to the surface, or other suitable site. Based the conceptual design of this equipment, this criterion has been met.

7.4.3 Criterion 4.2.3 (CRWMS M&O 2000f, Section 1.2.1.4) This criterion requires the system to transport and emplace WPs at an unspecified (TBD) rate. Although an emplacement rate was presumed in Assumption 5.2, this criterion has not been met.

7.4.4 Criterion 4.2.4 (CRWMS M&O 2000f, Section 1.2.1.14) This criterion requires the system to have the capability to install temporary ground support in order to facilitate recovery and retrieval operations. Sections 6.2.6 and 6.2.8 describe the restoration of a failed emplacement drift, including the installation of temporary ground support. Therefore, for this conceptual design, this criterion has been met.

7.4.5 Criterion 4.2.5 (CRWMS M&O 2000f, Section 1.2.1.16) This criterion requires that the system will have the capability to perform recovery while the Subsurface Emplacement Transportation System and the Site Communications System have failed at any location in the underground. Sections 6.2.4 and 6.2.6 discuss measures to temporarily install a road bed for specialized retrieval equipment, restore electrical power, and restore data communications. However, these mitigation measures are within an emplacement drift only, and therefore, this criterion has not been met.

7.4.6 Criterion 4.2.6 (CRWMS M&O 2000f, Section 1.2.3.1) This criterion requires that the system be designed to withstand and operate within the radiation environment in which the component is located. As discussed in Section 6.1.2.6, the equipment will be designed to operate in such an environment. Based on the conceptual design of this equipment, this criterion has been met.

7.4.7 Criterion 4.2.7 (CRWMS M&O 2000f, Section 1.2.3.4) This criterion requires that the system be designed to withstand and operate within the extreme subsurface temperature environment. As discussed in Section 6.1.2.6, the equipment will be designed to operate in such an environment. Based on the conceptual design of this equipment, this criterion has been met.

7.4.8 Criterion 4.2.8 (CRWMS M&O 2000f, Section 1.2.1.2) This criteria sets the operational life of the retrieval and restoration portions of the WERS. Sections 6.1.3 and 6.2.3 discuss this criterion and the ramifications on the conceptual plan. In reality, providing 135 years of capability is much more of an inspection, testing, and extended maintenance issue than a design issue. Maintaining an extended capability would require a substantial, on-going, equipment maintenance program including periodic replacement of time-sensitive parts, such as seals, hydraulic systems, lubricants, etc. Therefore, this criterion has not been met.

7.4.9 Criterion 4.2.9 (CRWMS M&O 2000f, Section 1.2.1.3) This criteria establishes that portions of the system shall support retrieval and restoration including provisions for a deferral of closure for up to 300 years after initiation of waste emplacement. As discussed in Sections 6.1.3 and 6.2.3, the ramifications and conceptual implications of such an extended closure period is difficult to address this conceptual design stage. The conceptual level design of the retrieval equipment provides little opportunity to "include provisions that support a deferral of closure" for such an extended time period. In reality, providing 300 years of capability is much more of an inspection, testing, and extended maintenance issue than a design issue. Maintaining an extended capability would require a substantial, on-going equipment maintenance program including periodic replacement of time-sensitive parts, such as seals, hydraulic systems, lubricants, etc. Any decision to defer closure for such an extended time would require significant planning and procedures for effective WERS fleet management and equipment replacement to provide the desired capacities. Therefore, this criterion has not been met.

7.4.10 Criterion 4.2.10 (CRWMS M&O 2000f, Section 1.2.1.5) Should retrieval of all emplaced WPs be required, this criteria defines the time limitation of 34 years for that retrieval. As discussed in Section 6.1.3, the retrieval of all WP would fall under normal retrieval, and would progress in reversed order and timeframe as the emplacement operations. Therefore, based on normal retrieval operations, this criterion has been met.

7.4.11 Criterion 4.2.11 (CRWMS M&O 2000f 1.2.1.6) This criteria sets the minimum number of WPs that the WERS must emplace and retrieve. All equipment is conceptually designed to accommodate these minimums, and therefore, complies with this criterion.

7.4.12 Criterion 4.2.12 (CRWMS M&O 2000f, Section 1.2.1.11) Per this criterion, the WERS equipment shall be able to transport retrieved WPs to the WHB or another surface location less than 4 kilometers from the WHB. The retrieval and transport equipment is rail mounted (see Section 6.1.3 and Section 6.1.2.5), however, until further confirmation of the equipment capabilities, this criterion has not been met.

7.4.13 Criterion 4.2.13 (CRWMS M&O 2000f, Section 1.2.3.4) This criterion requires that the portions of the system supporting emplacement shall have an operational life of 40 years following the start of emplacement. This analysis used the operational life as a basis for the 605 WP/year emplacement rate, as discussed in Assumption 5.2, and has not been addressed in the conceptual design of the retrieval equipment. In addition, providing 40 years of operational capability is much more of an inspection, testing, and extended maintenance issue than a design issue. Maintaining an extended capability would require a substantial, on-going, equipment maintenance program including periodic replacement of time-sensitive parts, such as seals, hydraulic systems, lubricants, etc. Therefore, this criterion has not been met.

7.4.14 Criterion 4.2.14 (CRWMS M&O 2000f, Section 1.2.1.15) As specified, the WERS shall be designed to retrieve WPs from emplacement drifts that have blocked ventilation. Section 6.2.6 addresses retrieval of WPs from emplacement drifts that have blocked ventilation, and therefore, complies with this criterion.

7.4.15 Criterion 4.2.15 (CRWMS M&O 2000f, Section 1.2.1.17) The retrieval system is fully capable of retrieving/recovering WPs from either end of an emplacement drift. This capability is especially advantageous during abnormal retrieval or recovery, as explained in Section 6.2.4, and therefore, this criterion has been met.

7.4.16 Criterion 4.2.16 (CRWMS M&O 2000f, Section 1.2.1.18) The system shall provide containment of radionuclides during WP transfer from the emplacement drift to surface. This capability is part of the conceptual design, as discussed in Section 6.3.4, and therefore, this criterion has been met.

7.4.17 Criterion 4.2.17 (CRWMS M&O 2000f, Section 1.2.1.22) The conceptual plan to re-rail and restore to normal operation any derailed system equipment is discussed in Section 6.2.4 with the re-railing equipment depicted in Figure 12 and Figure 13. Therefore, this criterion has been met.

7.4.18 Criterion 4.2.18 (CRWMS M&O 2000f, Section 1.2.1.23) As stipulated, the system shall transport to the surface any system equipment that cannot be re-railed and restored to normal operation. This criterion addresses a serious equipment situation and is addressed in Sections 6.2.4 and 6.2.6. Therefore, this criterion has been met.

7.4.19 Criterion 4.2.19 (CRWMS M&O 2000f, Section 1.2.2.1.4) The system shall provide features to recover from abnormal and/or design basis events including back-up measures to place and release loads in a safe manner. This capability is discussed in Section 6.2.4and 6.2.5, and therefore, this criterion has been met.

7.4.20 Criterion 4.2.20 (CRWMS M&O 2000f, Section 1.2.4.12) This criterion requires the system to operate with an electrical power feed provided by the Subsurface Emplacement Transportation System at both ends of an emplacement drift. As addressed in Section 6.2.4, the availability of electrical power from both sides of the emplacement drift enhances the ability to recover from either side of the emplacement drift. Therefore, this criterion has been met.

7.4.21 Criterion 4.2.21 (CRWMS M&O 2000f, Section 1.2.6.1) This criteria states that the system shall comply with the applicable provisions of "Standards for Protection Against Radiation" (10 CFR 20). As discussed throughout Section 6.3.1, 10 CRF 20 has been used in the derivation of contamination limits, and therefore, has been met.

7.4.22 Criterion 4.2.22 This requires that the emplacement drifts be line loaded with waste packages spaced with a minimum of 10 cm between the ends of adjacent waste packages. The emplacement gantry, as described in *Bottom/Side Lift Gantry Conceptual Design* (CRWMS M&O 2000a), has been conceptually design to emplace WPs end-to-end at 10 cm. The normal retrieval operations utilize the same emplacement gantry, and therefore, this criterion has been met.

7.4.23 Criterion 4.2.23 (CRWMS M&O 2000f, Section 1.2.6.12)This criterion requires that the design of the system comply with the applicable assumptions contained in the "Monitored Geologic Repository Project Description Document." The controlled project assumptions (CPA 004, CPA 005, CPA 019, and CPA 020) are inherent to the conceptual design of this system, and therefore, this criterion has been met.

7.4.24 Criterion 4.2.24 (CRWMS M&O 2000f, Section 1.2.2.1.9) The WERS system shall be designed in accordance with the project ALARA program goals and the applicable guidelines of "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low as is Reasonably Achievable." Section 6.3 defines how the contamination limits are established, monitored, and regulated. Although ALARA concerns were addressed, specific conceptual designs for ALARA were not made, and therefore, this criterion was not met.

7.4.25 Criterion 4.2.25 (CRWMS M&O 2000f, Section 1.2.1.21) The WERS equipment, which operate in an area with the potential for contamination, shall have appropriate surface finish and geometry to facilitate decontamination and limit the accumulation of fixed contamination. The WERS equipment is only conceptually designed, Section 6.3.4 discusses these requirements. This criteria is independent of the conceptual design and operation of the retrieval equipment and can be considered a detail design issue. Therefore, this criterion has not been met.

7.4.26 Criterion 4.2.26 (CRWMS M&O 2000f, Section 1.2.1.25) As specified in Section 6.3.4, the WERS shall be designed to decontaminate underground openings to below levels given in Section 222 of "U.S. Department of Energy Radiological Control Manual" or apply a fixative coating over contaminated surfaces, to prevent contamination spread. Although the WERS equipment is only conceptually designed, Section 6.3.4 discusses these requirements, and therefore, this criterion has been met.

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