OCRWM	DESIGN CALCULATION OR ANALYSIS COVER SHEET	1. QA: QA 2. Page 1

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8. Notes/Comments

Christine Linden authored Sections 1 through 7 and Section 8.8. Section 7.1, Repositroy Siting Constraints was written in conjunction with Roger Henning from the Natural Systems Department. Section 8.5, Performance Confirmation Facilites was written in conjunction with Jim Blink from the Decision Support and Documentation Department. Alan Linden performed all Vulcan design work and authored the remainder of the document.

Revision 00B was to correct three editorials (p. 36, 49 & 59), add a clarifying statement and reference (p. 65), correct an old reference (p. 26, 69 &71), update a reference (p. 70). and add the new reference (p.71). The revision was part of the close out of DR BSC(B)-02-D-035.

Revision 00C was a redesign, modified or deleted pages are identified on the Change History page.

Revision 00D was to correct editorials only,therefore no impact reviews were required. For changes see the Change History page.

Revision 00E was to correct editorials and clarify only,therefore no impact reviews were required. For changes see the Change History page.

Attachments	Total Number of Pages

RECORD OF REVISIONS

9. No.	10. Reason For Revision	11. Total # of Pgs.	12. Last Pg. #	13. Originator (Print/Sign/Date)	14. Checker (Print/Sign/Date)	15. QER (Print/Sign/Date)	16. Approved/Accepted (Print/Sign)	17. Date
00A	Issued in support of the LA baseline. This document supercedes ANL-SFS-MG-000001 REV 00 ICN 02 and ANL-WER-MD-000002 REV 00	115	V-1	A. F. Linden C. L. Linden	R. W. Elayer	L. Abernathy	F. Basamanowicz	08/22/02
00B	See Notes	115	V-1	A. F. Linden	J. Sheridan	L. Abernathy	F. Basamanowicz	02/06/03
00C	Supercedes Rev. 00B. Issued in support of the LA. Major change to accommodate rail based transporter.	86	V-1	A. F. Linden	J. Sheridan	L. Abernathy	M. Board	06/30/03
00D	Supercedes Rev. 00C	86	V-1	A. F. Linden	J. Sheridan	L. Abernathy	M. Board	07/16/03
00E	Supercedes Rev. 00D	86	V-1	A. F. Linden [signature] 9/25/3	J. Sheridan J. Sheridan 9/25/2003	L. Abernathy L. Abernathy 9/25/03	For M. Board R. BOUTIN R. Boutin 9/25/03	09/25/03

CHANGE HISTORY

Revision Number	Effective Date	Description of Change
00A	08/22/02	Initial issue. Supercedes ANL-SFS-MG-000001 REV 00 ICN 02 and ANL-WER-MD-000002 REV 00.
00B	02/06/03	Corrected editorials on p. 36, 49, and 59. Added references on p. 65 and 71. Added clarifying statement on p. 65. Corrected old references on p. 26, 69, and 71. Updated reference on p. 70.
00C	06/30/03	Updated contents of all pages except for 7 and 32 which were unchanged. Changed or added figures on p. 35, 38, 41, 45, 49, 55, 59, II-3, II-4, II-5, II-6, and III-2. Changed or added Tables on p. 18, 23, 39, 42, 43, 46, 47, 50, 51, 54, 56, 57, 58, I-1, I-2, I-3, I-4, II-2, III-3, III-4, III-5, III-6, III-7, III-8, IV-1, IV-2 and IV-3. Changed or added statements on p. 2, 8, 9, 17, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 33, 34, 36, 37, 39, 40, 43, 44, 47, 48, 51, 52, 53, 55, 60, 61, 62, 63, 64, I-1, II-1, II-2, III-1, IV-1 and V-1. The changed and added items refer to the page numbers in Rev. 00C. Deleted figure from p. II-17 of Rev. 00B Deleted tables from 65, II-1, II-3, II-4, II-6, II-7, II-8, II-9, II-11, II-12, II-14, II-15, II-16, II-17, II-19, II-20 and IV-1 of Rev. 00B. Deleted section from p. 47, 48, 49, 50, 51, 52, 53 and 54 of Rev. 00B.
00D	07/16/03	Corrected editorial on pages 3, 5, 53 and 61
00E	09/25/03	Modified Change History. Replaced figures on p. 35, 55, 58, II-3, II-4, II-5, II-6, and III-2. Added clarification on p. 43, 53. Modified Tables 3, 5, 8, 9, 10, 11,12 and III-1. Updated procedures on p.61.

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FIGURES

TABLES

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ACROYNMS

AP	Absorber Plates
BSC	Bechtel SAIC Company
BWR	Boiling Water Reactor
CD	compact disk
CFR	Code of Federal Regulations
CHn	Calico Hills nonwelded hydrogeologic unit
CR	Control Rods
CSNF	commercial spent nuclear fuel
DIRS	Document Input Reference System
DHLW	Defense high-level waste
DOE	U.S. Department of Energy
DTN	Data Tracking Number
ECRB	Enhanced Characterization of the Repository Block (drift)
EL	elevation
ESF	Exploratory Studies Facilities
FR	Federal Register
GFM	Geologic Framework Model
HLW	high-level waste
IPWF	immobilized plutonium waste form
LA	license application
MCO	multi-canister overpack
MTHM	metric tons of heavy metal
PC	performance confirmation
PTn	Paintbrush nonwelded hydrogeologic unit
PWR	Pressurized Water Reactor
RHH	repository host horizon
SNF	Spent Nuclear Fuel
SR	Site Recommendation
STA	station
TBM	tunnel boring machine

ACROYNMS (continued)

TBV	to-be-verified
Tptpln	lower nonlithophysal welded zone of Topopah Spring lithostratigraphic unit
Tptpv3	densely-welded (vitrophyre) subzone of Topopah Spring lithostratigraphic unit
TSw	Topopah Spring Tuff hydrogeologic unit
TSw1	densely welded devitrified lithophysal-rich tuff
TSw2	densely welded devitrified lithophysal-poor tuff
VPI	vertical point of intersection
WP	waste package

1. PURPOSE AND SCOPE

The purpose of this analysis was to develop an underground layout to support the license application (LA) design effort. In addition, the analysis will be used as the technical basis for the underground layout general arrangement drawings.

2. QUALITY ASSURANCE

This technical product was prepared in accordance with AP-3.12Q, *Design Calculations and Analyses*. In accordance with the *Q-List* (YMP 2001, p. A-9), the emplacement drifts are considered Quality Level 1, QL-1, and the remainder of the underground openings are considered conventional quality, CQ. Therefore, this work was subject to the requirements of the *Quality Assurance Requirements and Description* document (DOE [U.S. Department of Energy] DOE 2003).

The control of the electronic management of information was in accordance with Section 5.1.2 of AP-3.13Q, *Design Control*.

The control procedures followed for VULCAN V4.0NT (see Section 4.2) work were as follows:

1. Active VULCAN V4.0NT data files were saved to backup tape on a nightly basis and saved for a period of four weeks.

2. At the completion of specific milestones, the data files were backed up to a non-writable compact disk (CD) and sent to the records processing center.

3. The CD was labeled with generating program, originator, date, document number, and content description.

4. The CD also had an attached directory listing of the CD and description of the files contained on the CD.

3. DESIGN METHODOLOGY

The design of the underground layout was developed using the VULCAN V4.0NT software (see Section 4.2). The geological model for Yucca Mountain (see Section 5.1.3) was used as input into VULCAN V4.0NT. Using the model as a basis, the underground layout was developed in three-dimensions using the centerlines of the bottom of the excavations. The development of the layout was based on the inputs listed in Section 5, the assumptions listed in Section 6, the design constraints outlined in Section 7, and as described in Section 8. VULCAN V4.0NT was used throughout this analysis to extract information such as the coordinates, areas and lengths of the centerlines within the repository (see Attachments I, II, and III), and the excavation quantities specified in Sections 8.7 and 8.4. The underground layout is contained in two ".dxf" files (see Attachment V), one metric and one converted to imperial units .

The conversion factors used to convert from metric to Imperial units were:

1 foot = $^{1,200}/_{3,937}$ meters (ASTM E380-85, p. 24, footnote 13)

1 foot^3 / minute = 4.719474 x 10^{-4} meter^3 / second (ASTM E380-85, p. 26)

4. USE OF COMPUTER SOFTWARE

Computer software was used and is documented in accordance with AP-SI.1Q, *Software Management*.

4.1 OFF-THE-SHELF SOFTWARE

No off-the-shelf software was used in the preparation of this analysis.

4.2 QUALIFIED SOFTWARE

The VULCAN V4.0NT software system, STN: 10044-4.0NT-00 (BSC 2002f) was used for configuring the underground layout within the three-dimensional geologic model of Yucca Mountain. VULCAN V4.0NT is a geology and mine engineering computer design system developed by Maptek/KRJA Systems, Inc.

The VULCAN V4.0NT software was obtained from Software Configuration Management, was appropriate for the application, and was used only within the range of validation in accordance with AP-SI.1Q, *Software Management*. The VULCAN V4.0NT is installed on a Dell 340 workstation running on a Windows 2000 operating system (property tag number 150635).

The following models and files were used in the preparation of this analysis.

- The geologic model of Yucca Mountain, the VULCAN Geologic Framework Model (GFM) GFM3.1 representation (DTN: MO0003MWDVUL03.002).

- The electronic files for the underground layout as described in the *Design Evolution Study—Underground Layout*, (Board, M.; Linden, A.; and Zhu, M. 2002, Appendix B) including *areaofunits.dxf* and *proposedlayout.dxf*. These files were only used as the basis for starting the design of the layout.

Specific details of how the models and files were used are included in Sections 5.1.1 and 5.1.2.

The electronic output file from VULCAN V4.0NT can be found in Attachment V. Attachments I, II, III and IV summarize information extracted from the output file listed in Attachment V.

5. DESIGN INPUTS

The sources of design input, including technical information, codes and standards, applicable criteria and requirements are documented as appropriate in this section.

5.1 TECHNICAL INFORMATION

5.1.1 Design Evolution Study—Underground Layout

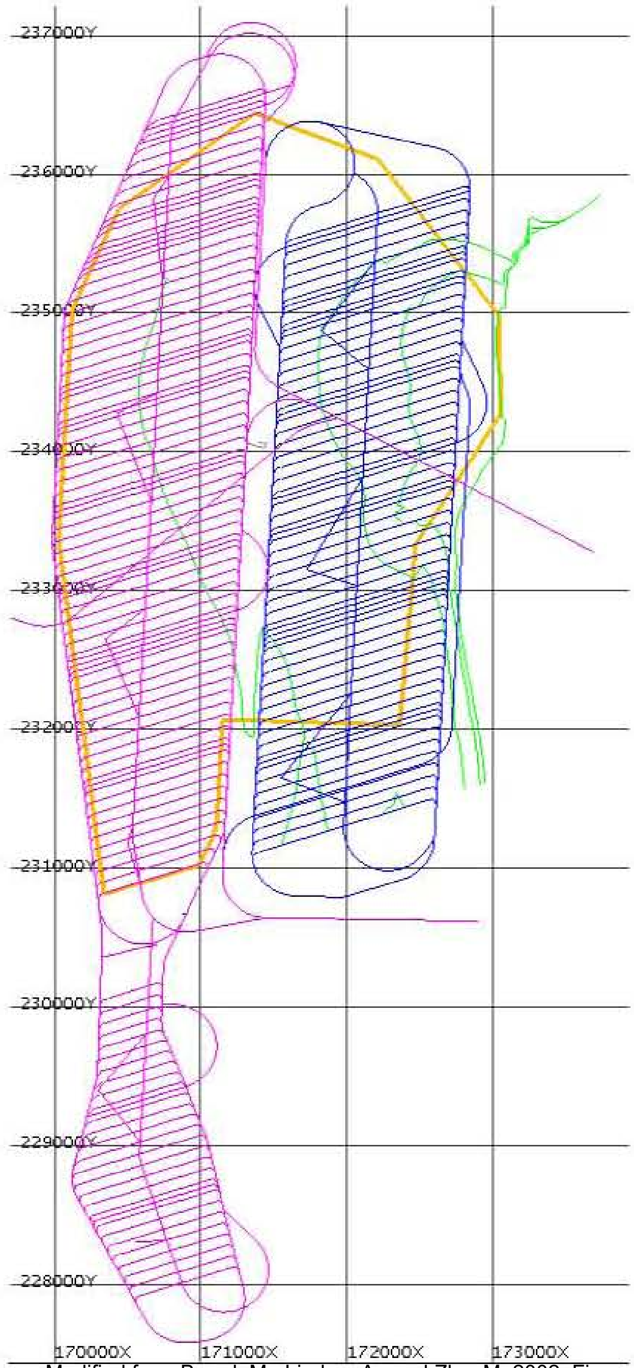
The *Design Evolution Study—Underground Layout* (Board, M.; Linden, A.; and Zhu, M. 2002) provides the results of a reevaluation of the repository footprint siting area and horizon selection, as well as the underground layout.

5.1.1.1 Footprint Siting Area and Horizon Selection Reevaluation

The underground layout reevaluation study resulted in a proposed alternative repository footprint boundary and horizon selection, driven primarily by an attempt to reduce uncertainties in performance assessment prior to the LA design studies. This footprint boundary is discussed in Sections 3, 4.3.1, and 4.3.2 of the *Design Evolution Study—Underground Layout* (Board, M.; Linden, A.; and Zhu, M. 2002, pp.3 to 14 and 19 to 23). This footprint (see Figure 1), illustrated with the previous layout for the site recommendation (SR), was used as the basis for developing the three-dimensional spatial constraints in this analysis. The design constraints governing the selection of this footprint and horizon, for this analysis, are further documented in Section 7.1.

5.1.1.2 Underground Layout Reevaluation

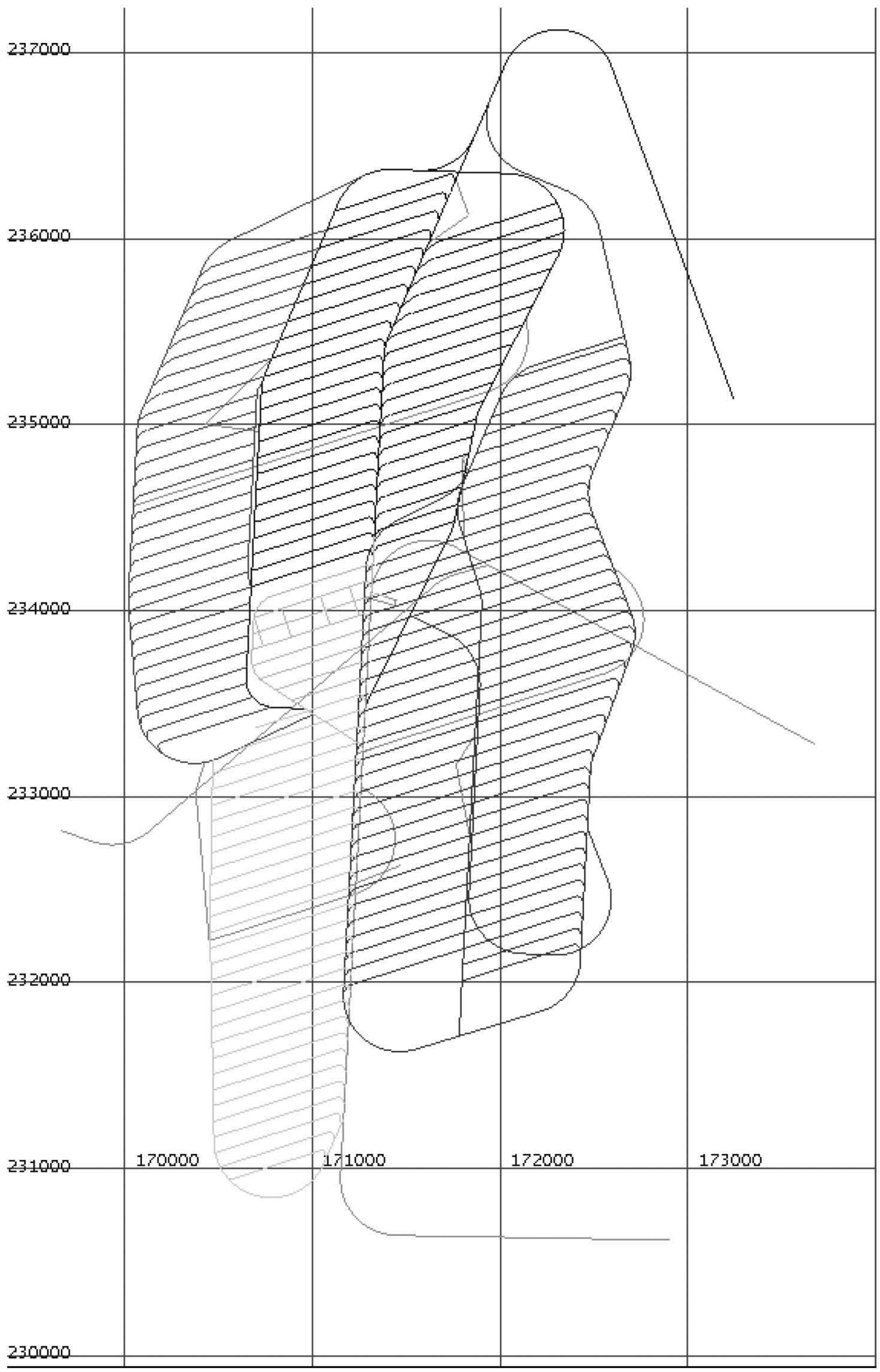
The design evolution study produced a layout configuration that had been modified significantly from the SR layout (see Figure 1) to produce a "modular" design (see Figure 2). This was accomplished by reducing the size of the emplacement panels, thereby reducing the excavation time necessary to establish areas and providing greater flexibility in meeting changeable waste receipt and thermal loading goals. The development of this layout is discussed in Section 5 of the *Design Evolution Study—Underground Layout* (Board, M.; Linden, A.; and Zhu, M. 2002, pp.33 to 53). This arrangement of underground openings was used as the basis in this analysis, for developing the layout in support of LA.



Source: Modified from Board, M.; Linden, A.; and Zhu, M. 2002, Figure 4-2

Figure 1. Alternative Repository Footprint Superimposed on the SR Layout

Note: The y-coordinate is the Northing and the x-coordinate is the Easting. The grid is 1 km squares.



Source: Modified from Board, M.; Linden, A.; and Zhu, M. 2002, Figure 5-4

Figure 2. Design Evolution Study—Underground Layout

5.1.2 Existing Facilities

The Exploratory Studies Facility (ESF), the East-West Cross Drift, also known as the Enhanced Characterization of the Repository Block (ECRB), and the Thermal Testing Facility Alcove will be incorporated into the underground layout. The following subsections outline the defining parameters of the ESF, ECRB, and the Thermal Testing Facility Alcove that are used in this analysis.

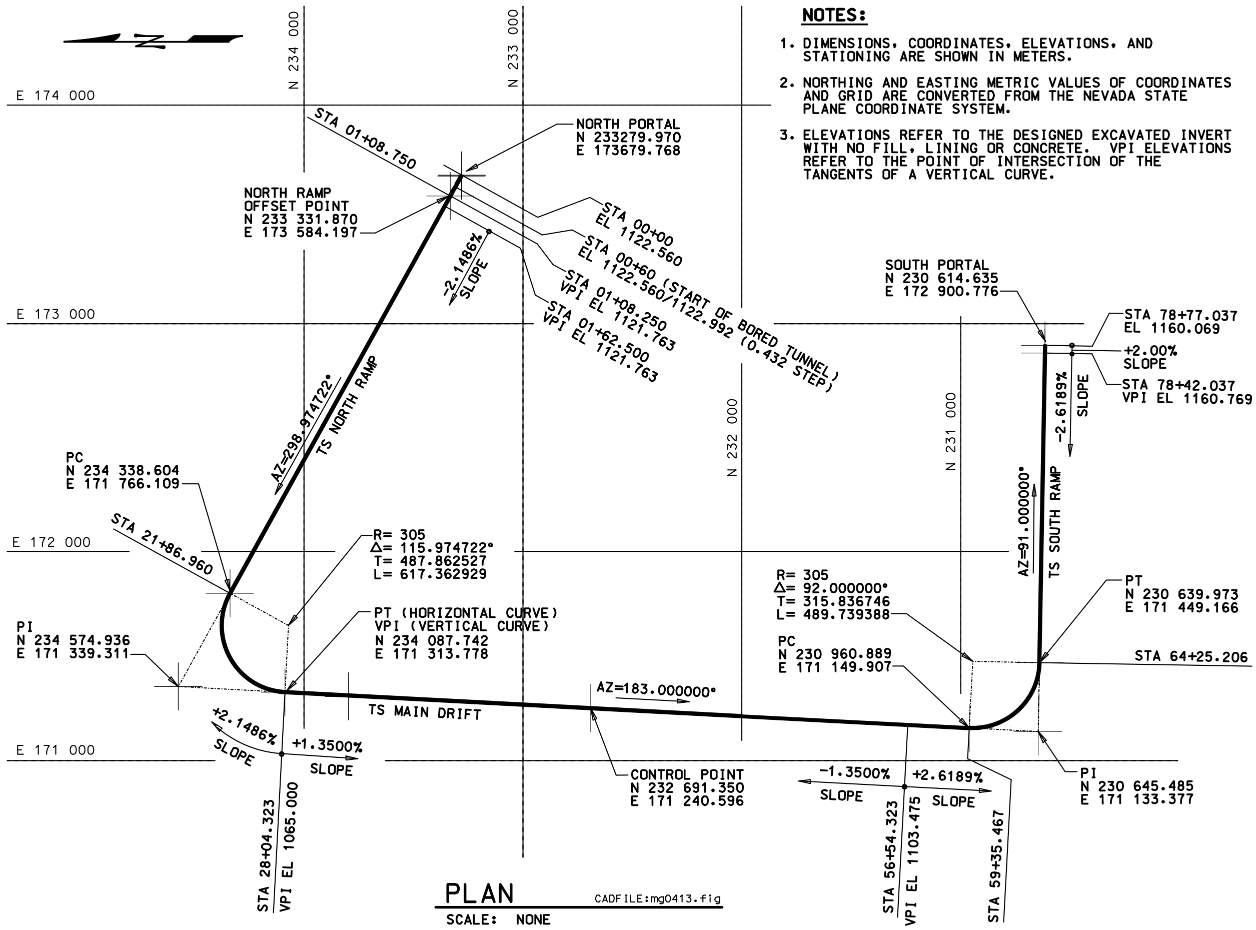
5.1.2.1 Exploratory Studies Facility

The existing ESF opening will be incorporated into the underground layout. The design and arrangement of the ESF, including gradients, coordinates, elevations, and azimuths, are illustrated in Figure 3 (CRWMS M&O 1996, p. 27).

5.1.2.2 East-West Cross Drift (Enhanced Characterization of the Repository Block)

The existing ECRB is incorporated into the underground layout. The design and arrangement of the ECRB is illustrated in Figure 4 (CRWMS M&O 1998a, Figure 1, and Attachment I) for reference only. The ECRB design as described below was outlined in the *East-West Cross Drift Starter Tunnel Layout Analysis* (CRWMS M&O 1998a, pp. 12 and 14) and is used as input to the layout.

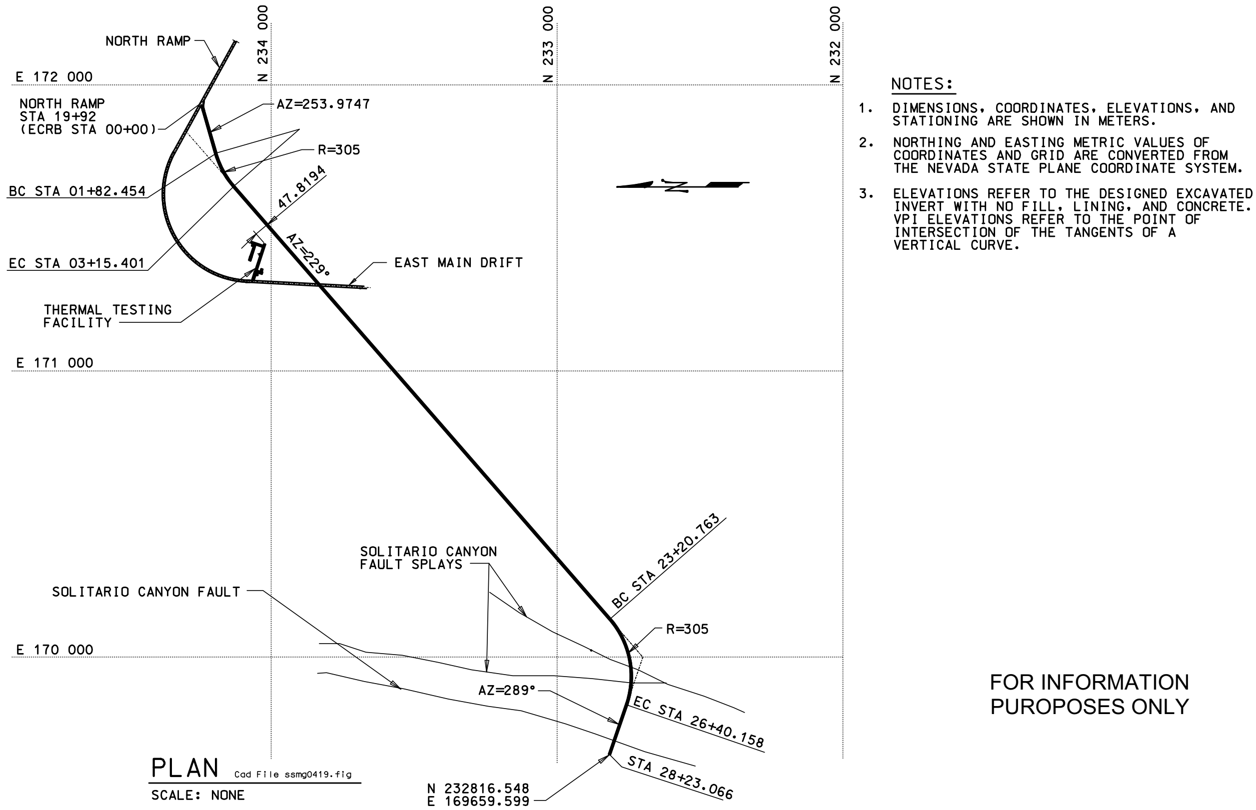
The grade of the excavated invert for the starter tunnel is +0.5 percent. The starter tunnel departs from the North Ramp at a 45-degree angle (an azimuth of 253.9747 degrees) and terminates at Station (STA) 00+26.400 meters. The elevation at the breakout from the North Ramp was calculated at 1,083.423 meters and the elevation of the start of the bored tunnel at launch at 1,083.842 meters. The starter tunnel is initially mined up to approximately STA 00+14.200 meters. The starter tunnel's excavated invert is offset 305 millimeters below the bored invert. The ECRB drift is a 5.0-meter diameter bored tunnel that starts at the end of the starter tunnel STA 00+26.400 meters and proceeds along an azimuth of 253.9747 degrees to the beginning of the first horizontal circular curve at STA 1+82.454 meters. The tunnel continues along the horizontal curve to the end of the curve at STA 3+15.401 meters. The tunnel proceeds along an azimuth of 229.0000 degrees to STA 3+25.401 meters at which point VPI #1 (vertical point of intersection) was located. The drift then continues at a +1.846 percent slope along 229.0000 degrees azimuth to the location of VPI #2 at STA 7+72.661 meters. VPI #2 is located at the plan view intersection of the ECRB and the East Main drift centerlines. VPI #2 is located at an elevation of 1,093.592 meters. From this point, the drift slopes at a +1.488 percent and continues along the 229.0000 degrees azimuth to the location of VPI #3 at STA 16+02.05 meters. VPI #3 is located at an elevation of 1,105.931 meters. The drift continues, from this point, at a slope of +0.886 percent and 229.0000 degrees azimuth to the beginning of the second horizontal curve at STA 23+20.763 meters. The drift continues along the curve at +0.886 percent slope to VPI #4 located at STA 24+67.146 meters. VPI #4 elevation is 1,113.597 meters. The drift then continues from this point at a slope of –3.0 percent to the end of the horizontal curve #2 located at STA 26+40.158 meters. From the end of curve #2, the drift continues at a –3.0 percent slope along a 289.0000 degrees azimuth to the terminal end of the drift located at STA 28+23.066 meters. The invert elevation at the terminal point is 1,102.919 meters.



EL = elevation

Source: CRWMS M&O 1996, p. 27

Figure 3. Exploratory Studies Facility



EL = elevation

Source: CRWMS M&O 1998a, Figure 1

Figure 4. Enhanced Characterization of the Repository Block

5.1.2.3 Thermal Testing Facility Alcove

The Thermal Testing Facility Alcove (CRWMS M&O 1997a and CRWMS M&O 1997b) will be incorporated into the underground layout. This alcove could provide access for an observation drift below the first few emplacement drifts in Panel 1 of the repository, as shown in Figure 5-1 of the *Design Evolution Study - Underground Layout* (Board, M.; Linden, A.; and Zhu, M. 2002, p. 35). The alcove is shown in Figure 4.

5.1.3 Geology and Stratigraphy

The stratigraphy of Yucca Mountain and the characterized block were defined in the *Determination of Available Repository Siting Volume for the Site Recommendation* (CRWMS M&O 2000a, Section 8). The Vulcan geologic model of Yucca Mountain, the *Vulcan GFM3.1 Representation* (DTN: MO0003MWDVUL03.002) uses the Nevada State Plane coordinate system, NAD 27 as its basis (converted to metric). The geologic model was compared with the *Determination of Available Siting Volume for the Site Recommendation* (CRWMS M&O 2000a, Section 8) to ensure accurate file transfer.

The geology of Yucca Mountain was used to locate ancillary openings and openings located about the emplacement area, within the repository host horizon (RHH).

A new version of the geologic model for Yucca Mountain, *GFM2000* (DTN: MO0012MWDGFM02.002), has been developed. However, this new version of the geologic model is not yet available as a VULCAN representation. A non-verified version has been compared with the current work and there appears to be no impact to the layout, but when the new VULCAN representation becomes available, an impact review will be required.

5.1.4 Emplacement Drift Orientation

The subsurface opening orientations relative to the orientation of the dominant rock joints effect opening stability. The orientation of emplacement drifts relative to the dominant rock joint is therefore, a consideration for ground stability and block size failure. This consideration is based on maximizing the stability of emplacement drifts, which minimizes maintenance in the emplacement drifts. In addition, the size of a block failure is affected by the drift orientation. Lesser stability may be acceptable in excavations other than the emplacement drifts because of their increased accessibility. The orientation of the emplacement drifts, an azimuth of 252 degrees, was established in the to-be-verified (TBV) resolution analysis, *TBV-361 Resolution Analysis: Emplacement Drift Orientation* (CRWMS M&O 1999, p. 26). This azimuth was used for the emplacement drift configuration within the underground layout.

5.1.5 Waste Inventory

The most recent information available for the waste package (WP) inventory for 70,000 metric tons of heavy metal (MTHM) is contained in *Thermal Inputs for Evaluations Supporting TSPA-LA, Supplement* (Williams, N.H. 2003, Table 3) and are outlined in Table 1.

Table 1. Waste Package Inventories

Type of WP	Nominal Quantity (WPs) Williams, N.H. 2003, Table 3	Nominal WP Length BSC 2003a,	
		Meters	inches
21 Pressurized Water Reactor (PWR) Absorber Plates (AP)	4,299	5.149	202.7
21 PWR Control Rods (CR)	95	5.149	202.7
12 PWR AP Long	163	5.707	224.7
44 Boiling Water Reactor (BWR) AP	2,831	5.171	203.6
24 BWR AP	84	5.171	203.6
Total commercial spent nuclear fuel (CSNF)	*7,472*		
5 DHLW Short/1 DOE SNF Short	1147	3.627	142.8
5 DHLW Long/1 DOE SNF Long	1,406	5.204	204.9
2 multi-canister overpacks (MCO)/2 DHLW	149	5.204	204.9
5 DHLW Long/1 DOE SNF Short	31	5.204	204.9
High-level waste (HLW) Long Only	679	5.204	204.9
Naval Short	144	5.367	211.3
Naval Long	156	6.002	236.3
Total DOE/HLW	*3,712*		
TOTAL	**11,184**		

This information has been used to demonstrate the capacity and flexibility of the underground layout.

5.2 CODES AND STANDARDS

There are no codes and standards used in the preparation of this analysis.

5.3 CRITERIA AND REQUIREMENTS

The criteria and requirements necessary to support the development of the underground layout are documented in this section. The development of the underground layout encompasses both the emplacement drift system, of which the emplacement drift is a component, and the tunneling system. Only the applicable criteria from these systems documented in this section. Project criteria were based on the design constraints of this document and are not addressed.

5.3.1 System Requirements

The following system requirements pertain to the underground layout configuration to support the LA design effort.

5.3.1.1 Multiple Barrier Requirement

The emplacement drifts are part of the EBS, which must include multiple barriers consisting of both natural and engineered barriers, to provide required postclosure performance (BSC 2002a, Section 3.1.1.1).

This requirement provides for consideration of multiple barriers that may include, among others, standoffs from natural features as discussed in Section 7.1.

5.3.1.2 Waste Inventory Requirement

The repository shall accept the 70,000 MTHM or equivalent of SNF/HLW of the types for disposal in the primary area of the repository (BSC 2002a, Section 3.1.2.1.1).

This requirement is in place to ensure that the repository layout has sufficient space for the waste disposal. The capability of the repository layout is discussed in Section 8.8.

5.3.1.3 Access Requirement

The subsystem will provide the necessary subsurface openings for use as pathways for access, transportation, ventilation, and monitoring activities during both repository construction and waste emplacement (BSC 2002e, Section 3.1.2.1.1).

The subsurface openings are discussed in Section 8

5.3.1.4 Performance Confirmation Opening Requirement

The subsystem will provide the necessary alcoves and performance confirmation drift openings for monitoring and testing subsurface conditions to support the Test and Evaluation Program that will be conducted throughout the preclosure period (BSC 2002e Section 3.1.2.1.2).

The Performance Confirmation openings are discussed in Section 8.5.

6. ASSUMPTIONS

Assumptions and the rationale for the suitability of the use of the assumptions are included in this section. These assumptions are consistent with the SR design unless otherwise noted.

6.1 OPENING SEPARATIONS

Assumption—Vertical separation between crossing drifts is assumed a minimum of 10 meters (33 feet) from the crown of the lower opening to the invert of the upper opening. The minimum separation (centerline-to-centerline) for non-emplacement drift running parallel is assumed as three diameters, based on the maximum diameter of the largest drifts.

Rationale—A minimum separation of three diameters of the largest of the two openings (centerline to centerline) is required for drifts that run perpendicular to one another. The basis of this is the rule of thumb that there is no interaction between drifts after a separation of three diameters regardless of ground stress. In low stress ground like Yucca Mountain, it is assumed that a 10 m vertical pillar is adequate based on the acceptability of a small degree of interference that could occur between drifts. This assumption will not be considered TBV since the assignment of the minimum separation between openings does not affect the total area required for emplacement of the specified WP inventory such that the conclusions of this analysis are impacted.

This assumption is used in Section 8.

6.2 TURNOUT CONFIGURATION

A number of assumptions are required for development of the emplacement drift turnout. The key assumptions are listed below with rationale as well as a description of the turnout itself. **Assumption**—It is assumed that the straight portion at the end of the turnout is 24 meters (79 feet).

Rationale—This straight portion of the turnout accommodates the setup and launch of the tunnel boring machine (TBM) as well as providing a docking area for the WP transporter for unloading of the WP in line with the emplacement drift. The WP transporter with the transfer dock is approximately 22 meters (72 feet) long (BSC 2001b, figure 3).

Assumption—It is assumed that the direct line of radiation from a 21 PWR WP positioned at the theoretical last emplacement spot will have a minimum standoff distance of 3 meters (10 feet) from the theoretical nose of the pillar.

Rationale— One of the functions of the turnout is to aid in reducing the radiation levels in the Mains and at the ventilation door. The direct line of radiation, the line-of-sight from the last emplaced WP in the emplacement drift, can increase the radiation levels in the mains and at the door. The theoretically last emplaced WP in the emplacement drift is assumed to be 1.5 meters (5 feet) from the start of the emplacement drift (see Section 6.3) and the projection of the direct line of radiation from this last WP will have a minimum assumed standoff distance of 3 meters (10 feet) from the theoretical intersects of the springlines of the main and the turnout. A 21 PWR

WP is used as it is the bounding WP for radiation levels. This is assumed to be sufficient to prevent the direct line of radiation from entering the mains or from hitting the ventilation door.

A transition from the East and West Mains into the emplacement drifts is required to support emplacement operations and accommodate the waste emplacement equipment. The emplacement drift turnouts will function as this transition from the main drifts into the emplacement drifts and support activities such as the TBM launch for emplacement drift excavation and WP transporter unloading and transfer of the WPs to the emplacement gantry. The emplacement drift turnout must also accommodate the WP transporter. A number of parameters within the turnout must be set by the physical constraints of the WP transporter. The curvature radius within the turnout is 61 meters in order to accommodate the minimum radius, which the transporter can negotiate (see Section 6.4). A difference in elevation of 0.8 meters between the interface of the bottom of the turnout and the bottom of the emplacement drift has also been used. This elevation step is required for interfacing with the transporter design for unloading the WP (see Section 6.4).

The length of the turnout depends on the change in azimuth between the centerline of the perimeter main and the centerline of the emplacement drift. As the angle between the main and the emplacement drift gets larger, the turnout length increases. The variances in the turnout gradients change with the turnout length, but are configured such that any water encountered within the turnout will drain out to the main.

If any of the assumptions that feed into the turnout configuration are modified, such as the length of the WP transporter, impact to the turnout configuration will need to be determined. These assumptions are not considered TBV since configuration of the emplacement drift turnouts does not affect the total area required for emplacement of the specified WP inventories.

This assumption is used in Section 8.

6.3 THEORETICAL END OF THE FIRST AND LAST WASTE PACKAGE

Assumption—A minimum standoff of the 15 meters (49 feet) will be maintained between the end of the last WP and the centerline of the exhaust main. A minimum of 1.5 meters (5 feet) between the end of the turnout and the first WP.

Rationale—To allow for off normal access from the exhaust main, a design allowance of 15 meters (49 feet) has been provided at the exhaust end of each emplacement drift, where emplacement of WPs is not planned. A minimum operational standoff distance of 1.5 meters (5 feet) will be required between the emplacement drift turnout interface and the closest placed WP in the emplacement drift. It is assumed that this standoff distance is sufficient to ensure that the WP is not located at the edge of the elevation difference between the turnout and the emplacement drift (see Section 6.4). This assumption is not considered TBV since the assignment of the standoff distances does not significantly impact the repository footprint or the emplacement drift allocations within that footprint.

This assumption is used in Attachment I.

6.4 TRANSPORTATION INTERFACE ASSUMPTIONS

Assumption—The portions of the underground layout, supporting emplacement shall be designed with a maximum grade of ±2.5 percent outside of emplacement drifts. The portions of the underground layout that do not support emplacement that might be supported by rail during construction shall be designed with a maximum grade of ± 5 percent. The portions of the underground layout that do not support emplacement and will not be supported by rail during construction shall be designed with a maximum grade of ± 15 percent.

Rationale—The assumption is needed to establish the maximum grade for all of the portions of the subsurface.

The maximum grade that the system will have to travel over to transport and emplace WPs will be in the ramps that access the subsurface repository. The ramps, which are already constructed, were inclined to allow access from the subsurface repository to the surface repository. There is no compelling reason for the rest of the subsurface facility that the system will be travelling on, to be inclined at a grade greater than the ramps (emplacement is planned via the North Ramp exclusively).

The *ESF Layout Calculation* (CRWMS M&O 1996, p. 27) identifies the design of the ESF including details of the ESF drift grades. As illustrated in Figure 3, the existing North Ramp grade is -2.1486 percent from the North Portal to the main drift. Rounding this grade up to +/- 2.5 percent provides a conservative margin for the maximum expected grade to be traversed by the system. A limitation for the grade is an important factor in the sizing of the transport locomotives for the current waste emplacement concept. Thus, the design grade for the rail-based WP transportation system is limited to 2.5 percent, maximum.

Construction grade constraints are established based on how the construction operations are supported. While TBM operations do not require rail to support them, long haulages are traditionally supported with rail. Goodman Equipment, a manufacturer of underground rail based equipment, has established haulage capacity tables up to 6 percent and use a 2 mile long ±4 percent haul as their sample calculation (Goodman Equipment Corporation 1971, pp. 1-3). Thus the maximum design grade for openings that could potentially use rail during construction is set conservatively at ±5 percent.

Currently areas that do not have rail and were excavated using rubber tired equipment have been driven at grades of approximately 15 percent (14.61% in the Thermal Testing Facility Alcove), (CRWMS M&O 1997b). Thus the maximum design grade for openings that will not incorporate rail is set at ±15 percent.

Assumption—The system shall operate within the curvatures identified in Table 2.

Table 2. Subsurface Curvatures

Location	Minimum Radius
Ramps and Mains	305 meters (1,001 feet)
Other Openings not used for Conveyor Mucking	100 meters (328 feet)
Within Emplacement Drift Turnouts	61 meters (200 feet)

Rationale—A minimum 305-meter (1,001-foot) radius curve along the centerline of the drift is used in the ramps and mains for conveyor muck handling. The curved sections of the turnouts have a 61-meter (200-foot) radius for the turning radii of the construction/development and emplacement operations equipment using rail transportation (BINFRA (Bechtel Infrastructure Corporation) 2002, pp.15-16). Final radii of the turnout walls will be dependent on equipment clearances and track requirements. Other openings in the repository that are not used for emplacement or conveyor muck handling will have at least a 100-meter (328-foot) radius for rail transportation.

Assumption—The system shall accommodate a minimum 0.80-meter (2.6-foot) difference in elevation between the bottom of the turnout and the bottom of the emplacement drift.

Rationale—The gantry carrier accommodates a minimum 0.80-meter (2.6-foot) difference in elevation between the bottom of the turnout and the bottom of the emplacement drift by hauling the waste emplacement gantry on the carrier bed (BSC 2001b, p. 41 and Figure 9).

These assumptions are not considered TBV since the WP transportation system interface does not significantly impact the repository footprint or the emplacement drift allocations within that footprint.

This assumption is used in Section 8.

6.5 SUBSURFACE VENTILATION SYSTEM INTERFACE ASSUMPTIONS

Assumption—The overall ventilation system will be similar to the ventilation system defined in *Site Recommendation Subsurface Layout* (BSC 2001c, Attachment IV).

Rationale—The ventilation system defined in the *Site Recommendation Subsurface Layout* (BSC 2001c) met all the thermal goals and set some reasonable ventilation constraints for a higher-temperature operating mode. By maintaining a similar system, the underground layout can be configured to minimize interference with the ventilation system and allow for future ventilation airflow analysis.

This assumption is used in Section 8.6.

7. DESIGN CONSTRAINTS

A number of design constraints have been used in defining the underground layout. These design constraints include those used to locate the repository in three-dimensional geologic space as well as locating and designing the surface openings such as the shaft collars and the portals.

7.1 REPOSITORY SITING CONSTRAINTS

7.1.1 Water Table Standoff

A standoff must be maintained from the closest edge of any emplacement drift to the top of the present-day water table (potentiometric surface).

This constraint is used to ensure that future climatic changes predicted to occur in the Yucca Mountain area do not cause the water table to rise to the level of the emplacement area of the repository. A standoff distance is established between the emplacement drifts and the present day water table to compensate for water table elevations higher than the present day water table.

Future climate states (monsoon, glacial transition, and full glacial) are expected to be wetter than the present day climate, and therefore, the water table is expected to rise. However, uncertainty exists regarding the amount of water table rise for each climate state. Mineral isotope studies suggest that the water table elevation could have been as much as 120 meters (394 feet) higher at the Yucca Mountain site (CRWMS M&O 2000b, Section 3.7.5.2). Estimates of the elevation of the water table under Yucca Mountain for wetter, glacial climatic conditions indicate that the water table could have been on the order of 100 m higher under these conditions (BSC 2003b, Section 6). Accordingly, an estimated water table rise of 120 meters (394 feet) is used for all flow fields using future climate states. It is noted that this does not directly constrain the footprint shown in Figure 1 (other constraints determine the layout). Additional studies are under way to better estimate water table rise under future climate conditions; the results will be taken into account in future design updates when they are available.

A standoff of 120 meters (394 feet) was maintained between the top of the present-day water table and any emplacement drift.

7.1.2 Perched Water Standoff

A standoff must be maintained from the closest edge of the emplacement drifts to any perched water. This standoff will avoid vaporization and mobilization of the perched water.

In order to prevent vaporization of any perched water near the emplacement area, a standoff of 30 meters (98 feet) is considered sufficient (Board, M.; Linden, A.; and Zhu, M. 2002, Section 3.2).

The hydrostratigraphic horizon where perched water has been observed and could potentially be important to the repository layout, is at the contact between the Calico Hills nonwelded hydrogeologic (CHn) unit, and the basal vitrophyre unit (Tptpv3) of the Topopah Spring Tuff hydrogeologic unit (TSw) (BSC 2001d, p. 46). Perched water has been observed at other horizons, particularly at locations outside the immediate layout area, but this is not important to layout design. The lower nonlithophysal welded lithostratigraphic unit (Tptpln) overlies the Tptpv3, and the repository layout may extend into the basal vitrophyre. Accordingly, the distance between the bottom of the Tptpln and the top of the CHn units is used to describe the proximity to the potential perching horizon. For purposes of this analysis, we have used the top of the vitrophyre to allow for perched water to exist at any depth within the vitrophyre. This depth is determined for the site area, based on the geology from the VULCAN GFM3.1 Representation (MO0003MWDVUL03.002).

The *Three Dimensional Thermo-Hydrologic Mountain-Scale UZ Model* (Wu et al., 1997, pp. 41 to 43) showed that nearby perched water could cause cooler temperatures in a repository after hundreds or thousands of years. Evaporation, transport, and subsequent condensation of perched water could increase the thermally driven fluxes of water vapor and liquid water in the host rock. However, this earlier modeling work was based on the viability assessment repository conceptual design, which was a hotter design than the current higher-temperature operating mode concept.

Thermal-hydrologic modeling, and observations from in-situ field thermal testing, show that evaporation of porewater from the matrix of the welded host rock is limited at temperatures below boiling as described in *Thermal Tests Thermal-Hydrological Analyses/Model Report* (BSC 2001e, Section 6.4) and the *Multiscale Thermohydrologic Model* (BSC 2001f, Sections 6.13.1 and 6.13.2). In addition, it is noted that thermal-hydrologic models predict high relative humidity at temperatures near boiling. These results mean that evaporation from a perched water zone would be similar to that from unsaturated tuff with the rock matrix nearly saturated, if the temperature does not exceed boiling. Accordingly, the extent of the boiling isotherm is used as the standoff distance to perched water.

Thermal-hydrologic simulations performed for the site recommendation design (similar to the higher-temperature operating mode concept) showed that regions up to 10 meters (33 feet) from the center of emplacement drifts would be dried out during the thermal period under the higher-temperature operating mode (BSC 2001a, Figures 4.3.5-2 and 4.3.5-3; and Section 4.3.6.4.2). For the higher-temperature operating mode, a region with temperatures as high as 95°C (203°F) extends to approximately 25 meters (82 feet) below the repository horizon (BSC 2002d, Figure 32). A standoff of 30 meters (98.4 feet) from the closest edge of the emplacement drifts was therefore selected to constrain the repository layout.

7.1.3 Standoff From Type I Faults

A standoff must be maintained from the closest edge of a repository opening to the main trace of any Type I fault zones.

The preference for location of the repository should be in the proposed repository block as defined by the block bounding faults. This block has been the principal focus of the site characterization studies completed to date. *Bedrock Geologic Map of the Yucca Mountain Area, Nye County, Nevada* (Day et al. 1998, p. 8) is a 1:24,000 scale map that includes the structural features in the vicinity of the main block. It is probable that other blocks suitable for a monitored geologic repository exist in the general area, but this main block has been the focus of studies to date. This area has been found to meet all the selection criteria and has been demonstrated to meet performance criteria for the natural systems. A detailed three-dimensional interpretation of the geology surrounding the location of the potential monitored geologic repository has been presented as the analyses detailing the construction and interpretation of the geology model GFM 3.1 and GFM2000 (MO0003MWDVUL03.002 and MO0012MWDGFM02.002).

Type I faults are identified in the *Staff Technical Position on Investigations to Identify Fault Displacement Hazards and Seismic Hazards at a Geological Repository* (McConnell, K.I.; Blackford, M.E.; and Ibrahim, A.B. 1992, p. 5) as:

> "Faults or fault zones that are subject to displacement and of sufficient length and located such that they may affect repository design and/or performance. As such, they should be investigated in detail. Only faults that are determined to be "Type I" are of regulatory concern, because it is those faults, both inside and outside the controlled area, that may require consideration in repository design, could have an effect on repository performance, or could provide significant input into models used to assess repository performance."

Based on *Seismic Design Basis Inputs for a High-Level Waste Repository at Yucca Mountain, Nevada* (CRWMS M&O 1998b, pp. 4-7 to 4-9), the only Type I fault identified in the immediate area of the repository is the Solitario Canyon fault. Although the Bow Ridge fault is not in the immediate area of the repository, it has also been classified as a Type I fault.

It is conservatively estimated that a 60-meter (197 foot) standoff from the trace of any Type I fault is adequate to reduce the impact of potential fault movement. The effects of fault displacement on emplacement drifts were analyzed in *Effects of Fault Displacement on Emplacement Drifts* (CRWMS M&O 2000d, p. 58 and BSC 2002b) using information derived from the *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada* (CRWMS M&O 1998c, Figures 8-10 and 8-13). This standoff considers potential fractured ground in proximity of the Type I fault and uncertainty as to where the fault is located at depth. The use of a 60-meter (197-foot) standoff for a LA design is conservatively applied. When initial construction activities in the area of Solitario Canyon are completed, the location of the fault should be better known and the condition of the rock in proximity to the fault can be examined first hand. A construction standoff could then be determined based on actual observations.

Repository openings can be located within this standoff only if justified with a site impact evaluation. This option is provided because of the complexity of Type I faults' impact on repository design and performance and to allow the use of site impact analyses in determining the suitability of openings within the Type I fault standoff.

7.1.4 Standoff From Paintbrush Nonwelded Hydrogeologic Unit

A standoff must be maintained from the closest edge of the emplacement drifts to the base of the Paintbrush nonwelded (PTn) hydrogeologic unit (Board, M.; Linden, A.; and Zhu, M. 2002, Section 3.2).

The large storage capacity and low fracture frequency of the highly porous PTn unit may effectively dampen transient pulses of infiltration and more evenly distribute the downward flow of water, as discussed in the *Unsaturated Zone Flow and Transport Model Process Model Report* (CRWMS M&O 2000b, p. 72). Thermal and hydrologic perturbations emanating from the repository could modify these attributes through the process of mineralogic alteration that reduces the matrix porosity. Establishment of a standoff between the repository and the base of the PTn would help limit the potential for changes due to repository hydrothermal effects.

The present hydrologic attributes of the PTn reflect the nonwelded glassy character of much of the rock in the unit. The rate at which the glassy tuff might alter is a function of temperature and of fluid content and composition, based on studies of natural alteration in the PTn. Local alteration of the PTn base under possible past hydrothermal conditions produced completely altered tuffs with mineral assemblages dominated by smectite, heulandite-clinoptilolite, opal-CT (partly crystalline silica), and quartz (Levy, S.S.; Norman, D.I.; and Chipera, S.J. 1996, pp. 786 to 789). Nothing is known for certain about the conditions of alteration, but paleogeothermometry data for similar mineral occurrences suggest temperatures as low as 40°C (104°F) (Levy, S.S. and O'Neil, J.R. 1989, Table 1).

The *FY 01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses* (BSC 2001a, p. 3-50, and Figures 3.3.5-4 and 3.3.5-5) predicts maximum temperatures at the base of the PTn of about 57°C (135°F) (Figure 3.3.5-4, without lithophysal cavities) or 70ºC (158°F) (Figure 3.3.5-5, with lithophysal cavities) after 1,000 years. Both predictions are for the higher-temperature operating mode repository cases. These figures (BSC 2001a, p. 3-50, and Figures 3.3.5-4 and 3.3.5-5) also show that the TSw unit 100 meters (328 feet) above the repository would reach a maximum temperature of approximately 80°C (176°F) at 1,000 years. This temperature may be taken as a surrogate for the temperature at the base of the PTn if the repository is located within 100 meters (328 feet) of the unit. Based on model #6 from the Mountain Scale Coupled Processes (TH) Model (CRWMS M&O 2000f), the maximum temperature approximately 100 meter (328 feet) above the repository is approximately 70°C (158°F) at 1000 years (CRWMS M&O 2000f, Figure 60). Model # 6 is a thermal load of 72.7 kW/acre and ventilation removing 70% of the heat for 50 years (CRWMS M&O 2000f, Table 5), which is similar to the current operating mode for LA.

For the lower-temperature case, *FY 01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses* (BSC 2001a, pp. 3-50 and 3-51 and Figure 3.3.5-6) predicts temperatures of 44 to 47°C (111 to 117°F) after 2,000 years (with or without lithophysal-cavity effects). The temperature in the TSw unit 100 meters (328 feet) above the repository at that time would be about 57°C (135°F).

Under the predicted higher-temperature thermal regimes cited above, complete avoidance of mineralogic change in the PTn probably is not achievable for the repository configuration imposed by other constraints. A 100-meter (328-foot) offset between the repository and the base of the PTn is compatible with other design constraints but would be likely to protect the PTn from alteration only under lower-temperature thermal regimes. The offset should provide some protection against alteration by keeping the PTn above the region of highly increased fracture-fluid flux (BSC 2001a, Figures 3.3.5-8 and 3.3.5-9).

7.1.5 Minimum Thickness of Paintbrush Hydrogeologic Unit

A minimum thickness of the PTn hydrogeologic unit must be maintained above the repository area to avoid excessive seepage from the ground surface (Board, M.; Linden, A.; and Zhu, M. 2002, Section 3.2).

Geologic information relevant to the assessment of repository performance includes the thickness and continuity of the PTn unit lying above the repository horizon. The PTn is believed to play an important role in unsaturated zone flow and transport. The high matrix porosity and large storage capacity of the PTn may enable this unit to dampen and distribute infiltration pulses above the horizon.

Geologic data indicate that the PTn ranges in thickness from greater than 165 meters (541 feet) beneath northern Yucca Mountain to about 15 meters (49 feet) in the south, with breaks in areal coverage along the Solitario Canyon, Iron Ridge, and Dune Wash fault systems (Attachment II). Where the PTn is thin or absent as the result of fault displacement, episodic infiltration/percolation events may perpetuate into the TSw rather than be attenuated and more evenly redistributed within the matrix of the PTn.

A minimum PTn thickness of 10 meters (33 feet) is incorporated into this analysis to define the underground layout to take advantage of the role that the PTn hydrogeologic unit plays in the unsaturated zone flow and transport. This constraint was imposed after recent studies indicate significant effects of the PTn unit in diverting and damping flow above the potential repository (BSC 2001a, Section 3.3.4.5.1). These studies also indicate that the PTn layer is required to constraint the impact of episodic pulses on seepage into the emplacement drifts.

7.1.6 Standoff From Calico Hills Nonwelded Hydrogeologic Unit

The emplacement drifts shall be located to limit thermally driven alteration of the CHn hydrogeologic unit (Board, M.; Linden, A.; and Zhu, M. 2002, Section 3.2).

The CHn, all or in part, lies between the potential repository horizon and the saturated zone. The importance of this unit for geologic-repository performance is derived from its hydrologic-flow properties and its potential for radionuclide sorption (BSC 2002c, Section 1.2). Both of these attributes are functions of mineralogic alteration and vary with location in the unit. Below the northern and eastern parts of the repository, the CHn is predominantly zeolitic tuff. The CHn below the southwestern part of the repository is mostly glassy tuff. In regions where the CHn mineralogy is transitional between the two varieties, complex interlayering of vitric and zeolitic tuff exists (BSC 2002c, p. 44 and II-4 to II-5).

Potential repository thermal alteration of the CHn may vary depending on the local mineralogy of the unit. Zeolitic CHn tuffs contain zeolites (predominantly clinoptilolite), smecite, and secondary silica, plus crystalline clasts that are primary constituents. The presence of the zeolites clinoptilolite and mordenite is associated with increased radionuclide sorptive capacity (BSC 2002c, p. 44), therefore, thermal alteration of clinoptilolite-bearing tuffs may lead to a reduction or loss of the radionuclide sorptive capacity associated with these tuffs. Two types of potential thermal alteration have been identified. First, clinoptilolite dehydrates significantly when heated to near the boiling temperature (Bish, D.L.; Carey, J.W.: Levy, S.S.: and Chipera, S.J. 1996, p.31 and Figure 7). The long-term effects of dehydration are unknown, but this treatment may lead to reduced sorptive capacity. The second type of potential alteration is the recrystallization of clinptilolite and other minerals to analcime, with a loss of sorptive capacity and probable modification of rock-transmissive properties. Natural alteration of clinoptilolite to analcime occurred between, 70 and 100ºC (158 to 212ºF) in boreholes G-1, G-2 and G-3 (Carey, J.W.; Bish, D.L.; and Chipera, S.J. 1996, Section III, pp. 4 and 5). Dissolution kinetic data for this reaction are insufficient to quantify the rate of alteration as a function of thermal regime and fluid chemistry.

Glassy CHn tuff is subject to thermal alteration essentially the same as the PTn unit. A net gain of sorptive zeolites and clays may be favorable for geologic-repository performance, but the accompanying changes in transmissive properties would increase the uncertainties in numerical predictions of flow and transport.

The *FY 01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses* (BSC 2001a, Figures 3.3.5-4 and 3.3.5-5) predicts for the higher-temperature repository, that the temperature in the upper 60 meters (197 feet) of the CHn will exceed 70°C (158°F) at 5,000 years. The temperature at the top of the CHn (910 masl) rises to about 73 to 74°C (163 to 165°F) after 5,000 years, and then declines to about 65°C (149°F) by 10,000 years. For the potential lower-temperature repository, a peak temperature of about 64°C (147°F) is reached at 5,000 years at the top of the CHn. By 10,000 years, the temperature throughout the CHn is about 61°C (142°F) (BSC 2001a, Figure 3.3.5-6).

Using the TSw unit 60 meters (197 feet) below the repository as a surrogate for the top of the CHn if it were 60 meters (197 feet) below the repository, peak temperatures of 80 to 82°C (176 to 180°F) are reached at 2,000 years for the higher-temperature repository. A peak temperature of 67°C (153°F) is reached at 5,000 years for the lower-temperature repository (BSC 2001a). Figures 3.3.5-4, 3.3.5-5, and 3.3.5-6). Based on model #6 from the Mountain Scale Coupled Processes (TH) Model (CRWMS M&O 2000f), the maximum temperature approximately 60 meters (197 feet) below the repository is approximately 75°C (167°F) at 1000 years (CRWMS M&O 2000f, Figure 60). Model # 6 is a thermal load of 72.7 kW/acre and ventilation removing 70% of the heat for 50 years (CRWMS M&O 2000f, Table 5), which is similar to the current operating mode for LA.

A standoff to the CHn hydrogeologic unit of 60 meters (197 feet) below the potential repository is recommended to limit recrystallization of the zeolitic CHn under lower-temperature repository conditions. Some amount of recrystallization is probably unavoidable under higher-temperature conditions. Alteration of the vitric CHn is likely to occur even under lower-temperature conditions, but alteration rates may be heavily influenced by the state of saturation in the CHn.

7.1.7 Repository Host Horizon

The emplacement drifts shall be located within the lower part of the lithophysal zone of the densely welded devitrified lithophysal-rich tuff (TSw1) unit and the entire densely welded devitrified lithophysal-poor tuff (TSw2) unit of the Topopah Spring Tuff.

The host rock for a repository should be able to sustain the excavation of stable openings that can be maintained during repository operations and that will isolate the waste for an extended period after closure. In addition, the rock should be able to absorb any heat generated by the WPs without undergoing significant changes that could threaten the site's ability to safely isolate the waste. The host rock should be of sufficient thickness and lateral extent to allow construction of a repository large enough to support the site's intended disposal capacity. Moreover, the amount of suitable host rock should provide adequate flexibility in selecting the depth, configuration, and location of the repository.

Studies to date have shown that the TSw has these features and characteristics. Experience gained from excavating the ESF demonstrates that openings can be excavated and maintained in the unit. The dense welding of the tuff originally occurred at temperatures of approximately 800°C (1,500°F); the results of laboratory and underground testing to date that the heat added by the emplaced waste would not adversely affect the stability of the underground repository (DOE (U.S. Department of Energy) 2002, p. 1-30).

The lower part of the lithophysal zone of the TSw1 unit and the entire TSw2 unit of the TSw will be referred to herein as the RHH as documented in the *Determination of Available Repository Siting Volume for the Site Recommendation* (CRWMS M&O 2000a, Section 5.2.3). That document identified potentially viable RHH areas outside of the main block, but those areas should not be considered until they have been adequately characterized. At this time, those areas would not be necessary to meet the needs of the repository being considered for licensing.

7.1.8 Overburden Cover

The emplacement drifts must be located sufficiently below the directly overlying ground surface to protect the waste from exposure to the environment and discourage intentional or inadvertent human intrusion into the facility.

Placement of the emplacement area within the RHH as described in Section 7.1.7, allows for adequate overburden cover. The canyons extending east from Yucca Crest cut down up to 100 meters (328 feet) into 12.7 ma Tiva Canyon Tuff, which equates to a maximum average canyon-cutting rate of about 0.8 cm/ka (YMP 1993, p. 54). The long-term average erosion rates of unconsolidated material from Yucca Mountain hillslopes is less than 0.6 cm/ka (YMP 1993, Table 5); while the rate of erosion of bedrock on ridge crests ranges from 0.1 to 0.3 cm/ka. Cosmogenic nuclide dating of lava flow surfaces at Black Cone in Crater Flat (1.0 ± 0.1 Ma by K-Ar dating) yields maximum removal of less than 20 cm of material since flow deposition (0.02 cm/thousand years) (CRWMS M&O 2000e, pp. 7.4-5 and 7.4-9).

The overburden thickness was included in the volume evaluation for the site recommendation design (CRWMS M&O 2000a, Section 8.1) and was not considered a limiting constraint for the determination of the repository siting volume. The siting volume evaluation was predominantly dictated from locating the repository with the RHH as described in Section 7.1.7. The minimum overburden thickness measured from the top of the RHH to the topographic surface is approximately 125 meters (410 feet). This measurement was performed using VULCAN and the GFM3.1 geologic representation of Yucca Mountain.

In addition, the underground layout allows for approximately 215 meters (705 feet) from the emplacement area to the overlying topographic surface. These measurements were performed using the VULCAN V4.0NT software, the Vulcan GFM3.1 Representation (DTN: MO0003MWDVUL03.002), GFM2000 (MO0012MWDGFM02.002), and the electronic file of the underground layout produced during the reevaluation (Board, M.; Linden, A.; and Zhu, M. 2002, Appendix B).

The overburden thickness above the repository area is considered sufficient to protect the waste from exposure to the environment and discourage intentional or inadvertent human intrusion into the facility.

7.2 OTHER DESIGN CONSTRAINTS

7.2.1 Operating Temperature Mode

The underground facility must be capable of supporting higher-temperature operating mode (0.1 m WP spacing) (Williams, N.H. 2003).

Due to the uncertainty about the ultimate thermal operating mode of the repository, the design must be flexible enough to encompass a range of postclosure thermal modes, as described in the *Yucca Mountain Science and Engineering Report, Technical Information Supporting Site Recommendation Consideration, Revision 1* (DOE (U.S. Department of Energy) 2002, Sections 2.1.4 and 2.1.5).

7.2.2 Modular Design

The underground layout shall be designed in such a manner that will permit modular design and/or construction in stages.

This will facilitate the start of operations at the repository after an initial construction stage and continuation of operations concurrently with subsequent construction stages. The *Design Evolution Study - Underground Layout* (Board, M.; Linden, A.; and Zhu, M. 2002, Section 5.2) discusses the need for the underground layout to be flexible in nature. This flexibility includes allowing the ease of separation of construction and emplacement activities, the ease of variation of WP loading densities, and waste receipts governed by policy changes. The reevaluation study accomplished this by significantly modifying the underground layout to produce a “modular” design. The modular design included emplacement panels that are reduced in size, thereby reducing the excavation time necessary to establish emplacement areas and providing greater flexibility in meeting changeable waste receipt and thermal loading goals (Board, M.; Linden, A.; and Zhu, M. 2002, Section 6).

7.2.3 Location of Surface Openings

The surface openings to the underground facility shall be located outside the probable maximum flood areas.

This constraint is provided to ensure that the entrances to the subsurface facility are located outside the probable maximum flood areas. A subsurface flood would have adverse effects on repository operation and could cause unpredictable impacts to the natural barrier due to water infiltration. Therefore, this constraint is provided to ensure that all subsurface entrances are protected from flood events.

The probable maximum flood areas are identified in the *Technical Basis Report for Surface Characteristics, Preclosure Hydrology, and Erosion* (YMP 1995, Figure 2.6.2-1) and the

Reference Information Base item for Environmental Characteristics: Flood Potential Characteristics (DTN: MO9804RIB00026.004, Figure 3).

7.2.4 Protection From Surface Water

The surface openings must be designed to prevent surface water from entering the subsurface facilities.

The surface pad around all openings to the subsurface facility, including ramp portals and shaft collars, will be designed to maintain a grade on the pads away from the portals or shaft collars.

In addition, a physical structure will be required at the collar of all shafts to prevent rainwater from directly entering the subsurface facility.

The ramps descend from the surface to the repository level. To limit the inflow of surface rainwater and runoff from entering the subsurface facility, a slight upward grade at the entrance to the ramp should be made. The grade of the north and south portals is sloped away from the entrance to the subsurface tunnels. Rainwater will not flow into the ramp unless ponding of the water occurs outside of the portal.

7.2.5 Subsurface Water Drainage

An overall repository grade must be provided such that the overall water drainage and accumulation is away from the emplacement areas.

Natural water infiltration is expected at the repository horizon. It is an objective of the repository design to minimize the amount of water accumulation in the emplacement drifts, thereby reducing the chance of water contacting with the WPs. The underground layout will be designed to ensure that water drainage is not towards the emplacement drifts. Layout of the drifts cannot preclude water contacting the WPs (due to expected natural infiltration), but this constraint will reduce the chance of water flow being focused into the emplacement drifts.

7.2.6 Postclosure Water Drainage

The underground layout will be configured for postclosure water drainage such that:

- Water entering the emplacement drifts will be allowed to drain directly into the surrounding host rock without draining along the drift for collection in a centralized location.
- Drifting above the emplacement level will not have direct connection to an emplacement drift such that water entering the overlying drift could flow by gravity through a manmade opening into the underlying emplacement drifts.
- Drifting above the emplacement level will be configured to slope so that any water that enters the drift can flow, by gravity, away from the emplacement area.

The subsurface facility will aid in the isolation of wastes and the achievement of the postclosure requirements established in regulations. This design constraint will result in a facility which, to the extent practical, minimizes the opportunities for water to contact the WPs after closure.

It is not possible to preclude water contact with containers solely by the layout of the drifts, but this constraint will help ensure that the layout does not allow water more than one chance to contact a container, and does not focus flow onto containers that otherwise may not have been reached.

7.3 REPOSITORY CAPACITY DESIGN CONSTRAINTS

7.3.1 Waste Package Standoff from Type I Faults

In the event that the standoff from repository openings to a Type I fault is waived following a site impact analysis, a standoff must be maintained between Type I faults and any WP. A standoff must be maintained between splays associated with Type I faults and any WP.

Areas that contain Type I faults should be avoided but, if unavoidable, they must be allowed for in engineering design. It is conservatively estimated that a standoff from the edge of the Type I fault or fault zone by 15 meters (49 feet) is adequate to reduce the impact of potential fault movement. Using a 15-meter (49-foot) standoff to establish usable drift length for the LA design is conservatively applied. When initial construction activities in the area of Solitario Canyon are completed, the location of the fault should be better known and the condition of the rock in proximity to the fault can be examined first hand. A standoff could then be determined based on actual observations.

Fault splays may provide a preferential pathway for water movement because of their association with Type I faults. The design should provide for control of water intrusion and therefore, an offset of WPs from unavoidable splays of Type I faults is considered prudent as a safeguard against this possible water intrusion. For engineering design, WPs should be offset 5 meters (16 feet) from the outside edge of any identified fault splay associated with a Type I fault. Using a 5-meter (16-foot) standoff to establish usable drift length for the LA design is conservatively applied. When construction activities are completed, the location of any fault splays should be better known and the condition of the rock in proximity to the fault splay can be examined first hand. A standoff could then be determined based on actual observations.

8. DEVELOPMENT OF THE LAYOUT

The approach to developing the underground layout configuration was to maximize, to the extent possible, the area for emplacement within the footprint boundary (see Section 5.1.1.1), while keeping the emplacement drift lengths, to the extent possible, at a nominal 600 meters (1969 feet).The underground layout is illustrated in Figure 5. Therefore most of the drifts are approximately 600 meters, but some are up to 800 meters long.

8.1 GENERAL LAYOUT DESCRIPTION

The repository will be developed in a series of modules or panels; the first panel will provide early access for emplacement of waste by 2010. The subdivision of the layout into smaller, integrated yet independent panels has the advantage of construction of emplacement areas without an initial commitment to develop large emplacement regions. This results in the following advantages:

- Faster availability of emplacement area
- Greater ease in separation of construction and emplacement operations
- Flexibility to accommodate possible changes in design or thermal loading strategies
- Potential for simpler ventilation design
- Better utilization of available repository emplacement area

Panels 1, 2, 3, and 4 (Figure 5) are located in the primary block area of the RHH. These panels will accommodate the 70, 000 MTHM case for LA. The lower block area of the RHH is available for expansion, but will not be designed as part of this report. The overall design has taken into account the need for flexibility during emplacement/construction. To increase the flexibility, the design has been set up to allow any of the remaining panels to be constructed after the first panel has been finished. This allows the emplacement sequence to change based on receipt rates or the funding levels, without requiring a change in the overall design. With a flexible sequence, it is not possible to determine the exact locations of the assembly/disassemble chambers for the TBMs. The tables showing opening sizes will only report the nominal size of the openings (i.e. 7.62 m), but a total number of chambers will be included in the summary of excavations (Section 8.7).

A description of the underground layout configuration as illustrated in Figure 5 and the influencing factors that affect the layout configuration are discussed in the following sections.

Attachment II shows the breakdown of the areas of each panel by its respective geologic unit, fault trace and boreholes around the emplacement areas

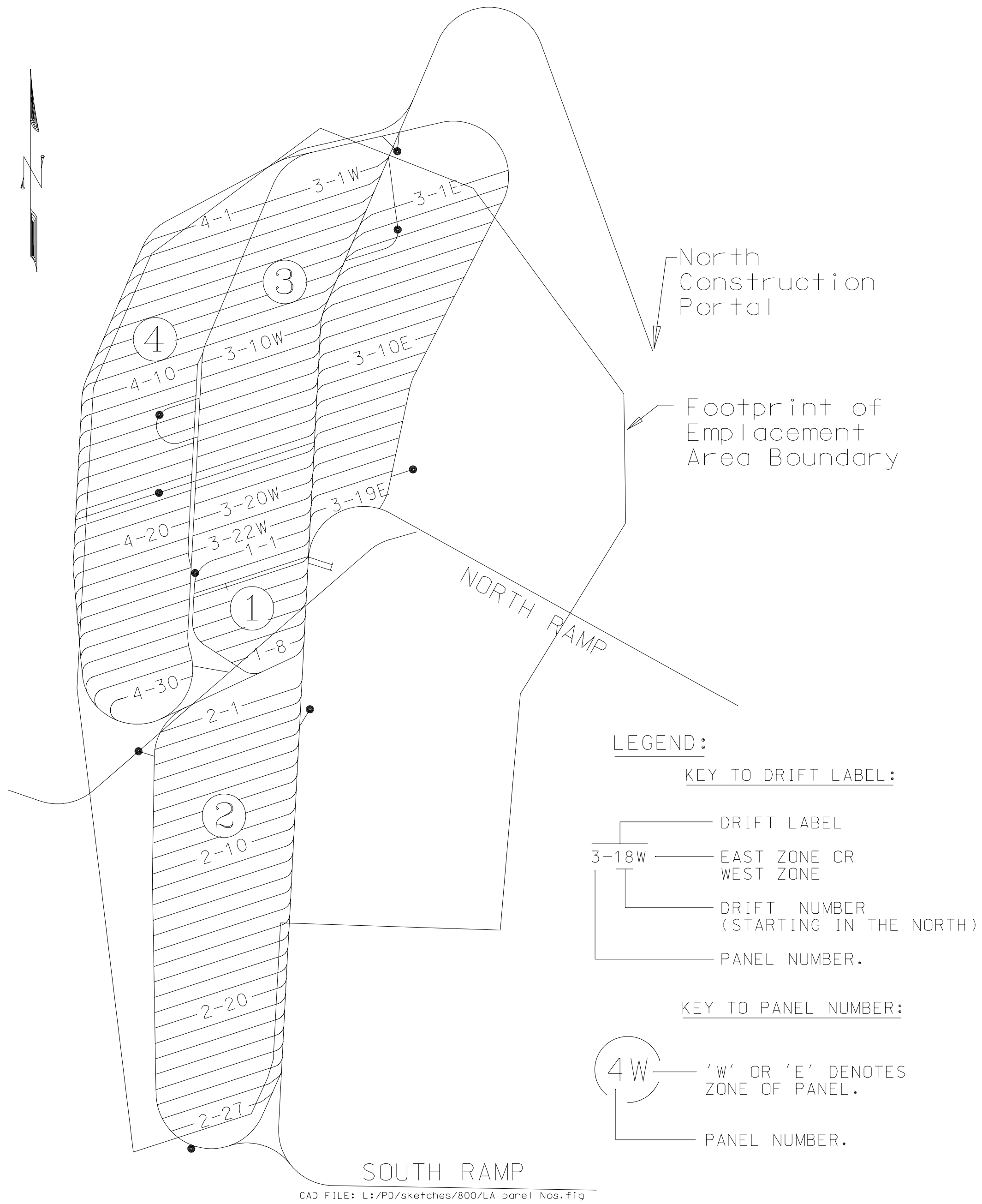


Figure 5. Underground Layout Configuration

8.2 EXISTING RAMPS AND MAINS

The ESF opening is located such that it can become an integral part of the underground layout configuration (see Section 5.1.2.1). The ramps in the ESF provide access to the RHH at gradients that accommodate rail transportation (see Section 6.4), where the North Ramp is at an approximate grade of –2.15 percent which will support emplacement and the South Ramp is at an approximate grade of -2.62 percent which will support construction.

The shape of the panels is slightly irregular. This was done to provide a high utilization of the available footprint area.

As shown in Figure 5, each panel consists of access mains on the intake side of the emplacement drifts and an exhaust main at the exhaust side of the emplacement drifts. The access mains and exhaust main are located in the same plane as that of the emplacement drifts. The panel details are found in Section 8.4.

8.3 NEW NORTH CONSTRUCTION RAMP

For access to the north end of the repository a new North Construction Ramp will be excavated (see Figure 5), that will connect with the ESF. This ramp will be sized at 7.62 meters (25 feet) and excavated with a TBM, similarly to the ESF ramps. To protect from potential flooding, the initial 10 meter (33 feet) lead in section (from the portal) of the ramp will be excavated up at a minimum of +1.00% grade. A TBM launch chamber similar to the one at the present North Portal, 20 meters long (66 feet) will be constructed after the initial lead in section. These two sections will be excavated by conventional drill and blast methods and will be sized 11 meters x 11 meters (36 feet x 36 feet).

Subsequently, this new North Construction Ramp will only be used for construction access, in addition to ventilation, allowing the North Ramp to be used exclusively for waste emplacement. This new ramp will be excavated at –5 % grade (Section 6.4) and will provide access to the upper repository block. This new North Construction Ramp will not be used for emplacement activities and will be used for construction access and muck handling only. It will be determined, during detailed design, whether the ramp grade should be reduced to allow greater flexibility for rail handling. If required, the ramp could be excavated at a flatter grade, which would result in a greater length. A change to the ramp gradient would not impact the overall configuration of the emplacement area.

It is proposed that the North Construction Portal be established in Isolation Ridge, up-slope and north of the existing North Portal. Here, the portal can be established at a location that is hidden from line-of-sight from the North Portal, helping to isolate construction from emplacement activities. Road access would be established from the north, allowing a construction camp to be developed, which would be physically isolated from the waste handling facilities at the North Portal. After the North Construction Portal is established, construction activities would be restricted to the new North Construction Portal and South Portal, with waste handling through the North Portal only.

The location of the new North Construction Portal is approximately 2,000 meters (6,562 feet) from the existing north portal.

There may be other locations where a portal could be located that would also meet most of these objectives. The selection of the current location was to minimize the overall ramp length. If the overall grade of the ramp were modified, the portal position would need to be reevaluated.

8.4 PANEL DESCRIPTIONS

The following sections provide descriptions of each of the emplacement panels.

8.4.1 Panel 1

For Panel 1, Figure 6 shows the various openings that will be constructed. Table 3 lists the actual sizes and lengths of these openings (lengths have been rounded to the nearest meter) along centerline.

The initial emplacement panel will be located within the central section of the overall layout (Figure 6) and will utilize the ESF for access to the repository horizon. The size of the panel is small in comparison to the other panels in the repository. This was done so that the panel could be developed and equipped for waste emplacement in 2010. It is then necessary for subsequent construction activities to bypass the panel for continued development.

The exhaust main in Panel 1 will be driven with a 5.5 m TBM. This opening is sized smaller than the other exhaust mains because of the smaller volume of air required to move though it and by sizing it the same as the emplacement drifts, there will be better utilization of the excavation equipment. The first portion of this main will also be used as access to Panel 2 and 4. This portion will have to be slashed to 7 x 7 m (23 x 23 ft) to support activities in these other two panels. This excavation will not have to be done in conjunction with Panel 1.

Portions of Panel 3 (i.e. East Drift 19) could require to be excavated along with Panel 1, depending on what is required to isolate construction from emplacement. This is not addressed in this report, but a detailed construction sequence will be required for detailed design.

Panel 1 consists of eight emplacement drifts (Figure 6) with a total useable waste emplacement length of 4,092 meters (13,426 feet). Provision is made for potential use of one or more emplacement drifts as Test and Evaluation drifts. An observation drift and instrumentation alcove is provided beneath Emplacement Drift 3 for instrumentation and observation purposes. The observation drift is excavated westward as an extension from the bottom of the existing Thermal Testing Facility Alcove (see Section 5.1.2.3). Details of the actual length of emplacement drifts, useable lengths and bounding end point coordinates for Panel 1 can be found in Attachments I and III.

The emplacement area of Panel 1 will be developed from the north to the south. The North Ramp will supply the intake ventilation for the panel during emplacement and the exhaust will be through Exhaust Raise 1 located at the north end of the panel between Emplacement Drifts 1 and 2. By constructing the panel in this manner it is possible to turn over the panel for emplacement in stages, as little as the first two drifts could be turned over in the first package. The overall drainage pattern for Panel 1 is that everything will drain to the bottom of the exhaust raise, except for the PC observation drift which has its own drainage pattern (See Section 8.5).

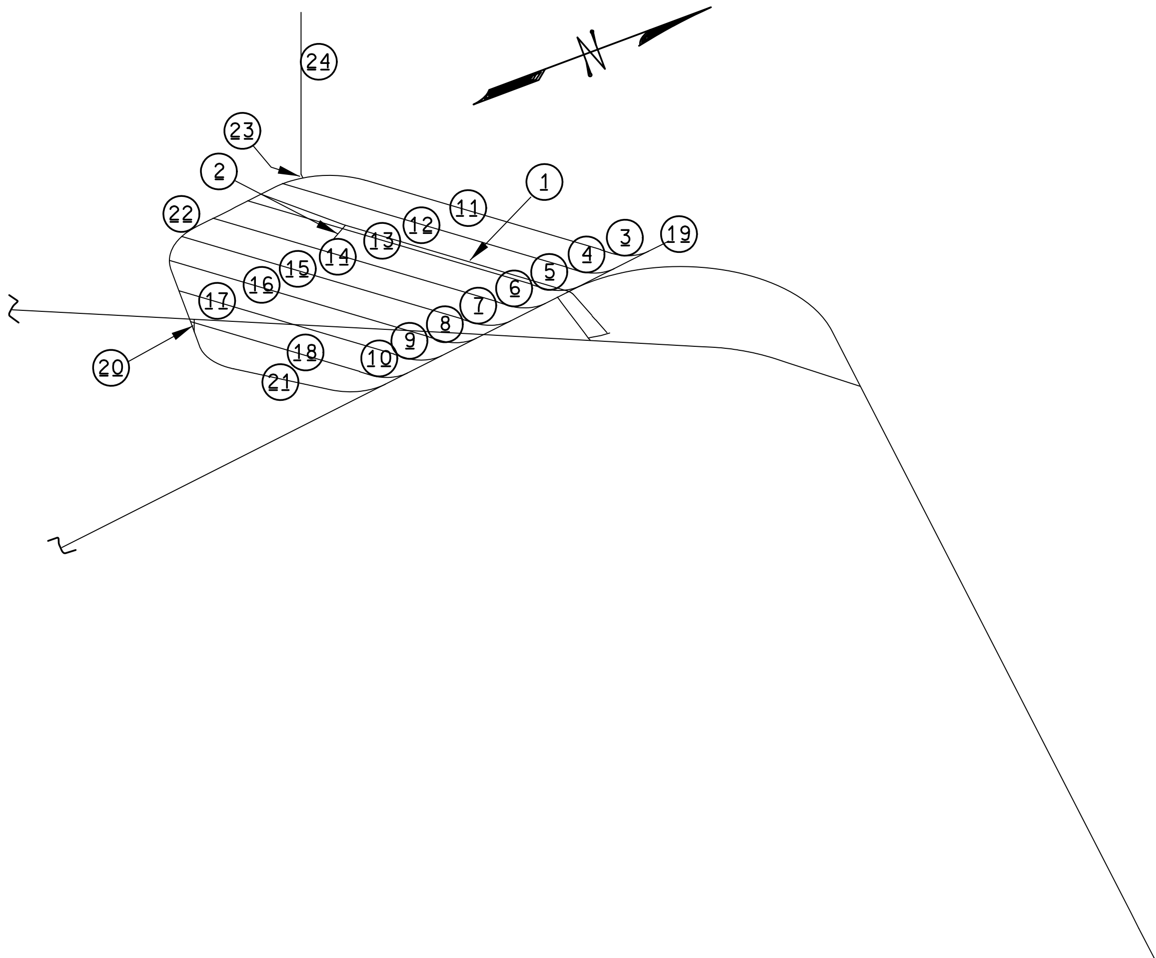


Figure 6. Panel 1

* Note: Numbers refer to the headings in Table 3

Table 3. Panel 1 Opening Sizes and Lengths

Heading		Size		Plan Length	
		meters	feet	meters	feet
1	PC Observation Drift	5 x 5	16 x 16	739	2425
2	Alcove	5 x 5	16 x 16	40	131
3	Drift Turnout # 1	7 x 8	23 x 26	97	318
4	Drift Turnout # 2	7 x 8	23 x 26	97	318
5	Drift Turnout # 3	7 x 8	23 x 26	97	318
6	Drift Turnout # 4	7 x 8	23 x 26	97	318
7	Drift Turnout # 5	7 x 8	23 x 26	97	318
8	Drift Turnout # 6	7 x 8	23 x 26	97	318
9	Drift Turnout # 7	7 x 8	23 x 26	97	318
10	Drift Turnout # 8	7 x 8	23 x 26	97	318
11	Drift # 1	5.5 diameter	18 diameter	494	1621
12	Drift # 2	5.5 diameter	18 diameter	596	1955
13	Drift # 3	5.5 diameter	18 diameter	597	1959
14	Drift # 4	5.5 diameter	18 diameter	597	1959
15	Drift # 5	5.5 diameter	18 diameter	591	1939
16	Drift # 6	5.5 diameter	18 diameter	544	1785
17	Drift # 7	5.5 diameter	18 diameter	451	1480
18	Drift # 8	5.5 diameter	18 diameter	355	1165
19	East Main Extension	7 x 7	23 x 23	258	846
20	Construction Vent Raise to ECRB	2 diameter	7 diameter	29	95
21	Main to Panels 2 and 4 (#1 in Panel 2)	5.5 diameter*	18 diameter	303	994
22	Exhaust Main	5.5 diameter	18 diameter	895	2937
23	Access to Exhaust Raise # 1	5 x 5	16 x 16	13	43
24	Exhaust Raise # 1	5 diameter	16 diameter	371	1217

* Will initially be excavated at 5.5 m diameter, but will be slashed to 7 x 7 m later

8.4.2 Panel 2

For Panel 2, Figure 7 shows the various openings that will be constructed . Table 4 lists the actual sizes and lengths of these openings (lengths have been rounded to the nearest meter) along centerline.

Panel 2 is developed at the southern end of the primary area (Figure 5) and utilizes the southern portion of the ESF as its eastern limit. A short new main loop is needed to provide the western limit of the panel. This main will incorporate a portion of the main developed during Panel 1 construction and will be slashed to a 7 x 7 m (23 x 23 ft) opening. Panel 2 will utilize the existing ESF as its intake main.

Panel 2 consists of 27 emplacement drifts with a total useable waste emplacement length of 18,850 meters (61,842 feet). Details of the actual length of emplacement drifts, useable lengths and bounding end point coordinates for Panel 2 can be found in Attachment I and III.

The emplacement area of Panel 2 will be developed from the north to the south. The intake for the northern portion of Panel 2 will be supplied from Intake Shaft 3 and the southern portion will be supplied from the South Ramp. ECRB Exhaust Shaft will ventilate the northern portion, Exhaust Shaft 3 will ventilate the southern portion of Panel 2. During construction of Panel 2, Exhaust Shaft 3 will be accessed as a construction intake. By accessing Exhaust Shaft 3 early for Panel 2 construction some of the safety concerns due to dust can be mitigated. Also if there are concerns with the overall length of the exhaust main for construction without flow through ventilation, emplacement drifts can periodically be excavated across the panel to supply construction intake air. A conveyor main (Heading 3, Table 4) has been shown connecting the South Ramp with the Exhaust Main. This opening has been proposed to help with construction, but a detailed analysis on whether it is cost effective has not been done. It is included in this report to help bound total potential excavations, but a feasibility study will be required during detailed design to justify it.

The emplacement drift turnover sequence will start from the north and progress south. The initial turnover package will include the portion of Panel 2 north of the access to Intake Shaft 3. Construction access for Panel 2 will only be from the South Ramp. The overall drainage pattern for Panel 2 is from the south to the north. Panel 2 connects with Panels 1 and 4 and will drain to Exhaust Shaft 2.

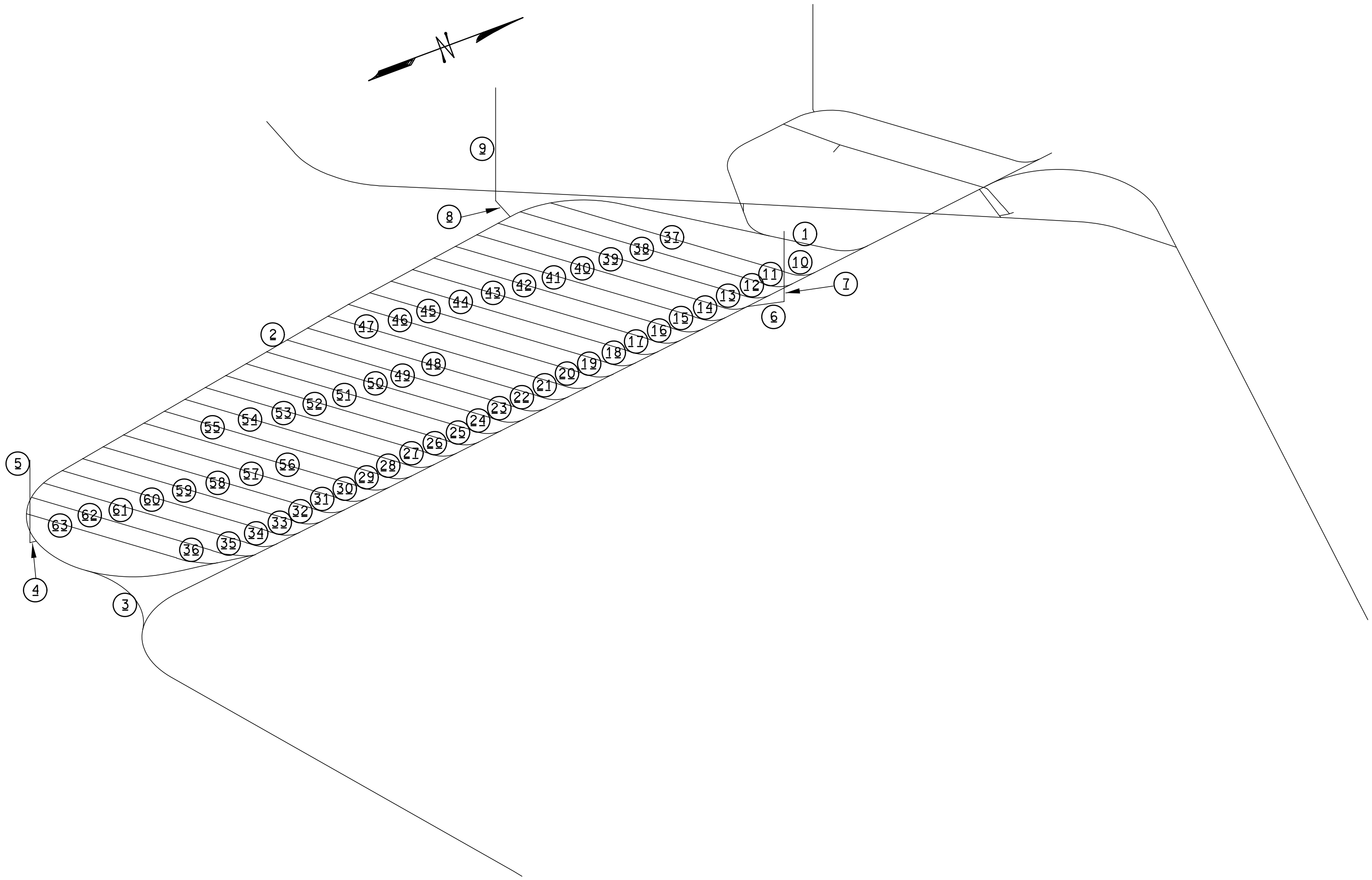


Figure 7. Panel 2

* Note: Numbers refer to the headings in Table 4

Table 4. Panel 2 Opening Sizes and Lengths

Heading		Size		Plan Length	
		meters	feet	meters	feet
1	Main to Panels 1 and 4 (#21 in Panel 2)	7 x 7 *	23 x 23	303	994
2	Main	7.62 diameter	25 diameter	3744	12283
3	Construction Conveyor Drift	7.62 diameter	25 diameter	372	1220
4	Exhaust Shaft # 3 Access	8 x 8.5	26 x 28	20	66
5	Exhaust Shaft # 3	8 diameter	26 diameter	292	958
6	Intake Shaft # 3 Access	8 x 8.5	26 x 28	109	358
7	Intake Shaft # 3	8 diameter	26 diameter	248	814
8	ECRB Exhaust Shaft Access	8 x 8.5	26 x 28	91	299
9	ECRB Exhaust Shaft	8 diameter	26 diameter	398	1306
10	Drift Turnout # 1	7 x 8	23 x 26	97	318
11	Drift Turnout # 2	7 x 8	23 x 26	97	318
12	Drift Turnout # 3	7 x 8	23 x 26	97	318
13	Drift Turnout # 4	7 x 8	23 x 26	97	318
14	Drift Turnout # 5	7 x 8	23 x 26	97	318
15	Drift Turnout # 6	7 x 8	23 x 26	97	318
16	Drift Turnout # 7	7 x 8	23 x 26	97	318
17	Drift Turnout # 8	7 x 8	23 x 26	97	318
18	Drift Turnout # 9	7 x 8	23 x 26	97	318
19	Drift Turnout # 10	7 x 8	23 x 26	97	318
20	Drift Turnout # 11	7 x 8	23 x 26	97	318
21	Drift Turnout # 12	7 x 8	23 x 26	97	318
22	Drift Turnout # 13	7 x 8	23 x 26	97	318
23	Drift Turnout # 14	7 x 8	23 x 26	97	318
24	Drift Turnout # 15	7 x 8	23 x 26	97	318
25	Drift Turnout # 16	7 x 8	23 x 26	97	318
26	Drift Turnout # 17	7 x 8	23 x 26	97	318
27	Drift Turnout # 18	7 x 8	23 x 26	97	318
28	Drift Turnout # 19	7 x 8	23 x 26	97	318
29	Drift Turnout # 20	7 x 8	23 x 26	97	318
30	Drift Turnout # 21	7 x 8	23 x 26	97	318
31	Drift Turnout # 22	7 x 8	23 x 26	97	318
32	Drift Turnout # 23	7 x 8	23 x 26	97	318
33	Drift Turnout # 24	7 x 8	23 x 26	97	318
34	Drift Turnout # 25	7 x 8	23 x 26	97	318
35	Drift Turnout # 26	7 x 8	23 x 26	123	404
36	Drift Turnout # 27	7 x 8	23 x 26	123	404
37	Drift # 1	5.5 diameter	18 diameter	753	2470
38	Drift # 2	5.5 diameter	18 diameter	779	2556
39	Drift # 3	5.5 diameter	18 diameter	779	2556
40	Drift # 4	5.5 diameter	18 diameter	775	2543
41	Drift # 5	5.5 diameter	18 diameter	772	2533
42	Drift # 6	5.5 diameter	18 diameter	769	2523
43	Drift # 7	5.5 diameter	18 diameter	766	2513
44	Drift # 8	5.5 diameter	18 diameter	763	2503
45	Drift # 9	5.5 diameter	18 diameter	759	2490
46	Drift # 10	5.5 diameter	18 diameter	756	2480
47	Drift # 11	5.5 diameter	18 diameter	750	2461
48	Drift # 12	5.5 diameter	18 diameter	744	2441
49	Drift # 13	5.5 diameter	18 diameter	737	2418
50	Drift # 14	5.5 diameter	18 diameter	731	2398
51	Drift # 15	5.5 diameter	18 diameter	725	2379
52	Drift # 16	5.5 diameter	18 diameter	718	2356
53	Drift # 17	5.5 diameter	18 diameter	712	2336
54	Drift # 18	5.5 diameter	18 diameter	706	2316

Heading		Size		Plan Length	
		meters	feet	meters	feet
55	Drift # 19	5.5 diameter	18 diameter	699	2293
56	Drift # 20	5.5 diameter	18 diameter	693	2274
57	Drift # 21	5.5 diameter	18 diameter	687	2254
58	Drift # 22	5.5 diameter	18 diameter	680	2231
59	Drift # 23	5.5 diameter	18 diameter	674	2211
60	Drift # 24	5.5 diameter	18 diameter	668	2192
61	Drift # 25	5.5 diameter	18 diameter	655	2149
62	Drift # 26	5.5 diameter	18 diameter	583	1913
63	Drift # 27	5.5 diameter	18 diameter	485	1591

* Will initially be excavated at 5.5 m diameter, but will be slashed to 7 x 7 m later

8.4.3 Panel 3

For Panel 3, Figure 8 shows the various openings that will be constructed. Table 5 lists the actual sizes and lengths of these openings (lengths have been rounded to the nearest meter) along centerline.

Panel 3 is located in the primary block of the RHH and will be developed to the immediate north of Panel 1 (Figure 5), using the new North Construction Ramp (see Section 8.3) for construction access. Panel 3 is divided into two zones, the east and the west. The zones share a common intake main that runs down the middle of the panel. The outside perimeter of the panel forms the exhaust main.

Panel 3 consists of 41 emplacement drifts (Figure 8) with a total useable waste emplacement length of 24,000 meters (78,740 feet). 22 drifts are located in the west zone making up 13,272 meters (43,543 feet) of emplacement length and 19 drifts are located in the east zone making up 10,728 meters (35,197 feet) of emplacement length. Both zones will be constructed simultaneously and turned over together. Details of the actual length of emplacement drifts, useable lengths and bounding end point coordinates for Panel 3 can be found in Attachments I and III.

The emplacement area of Panel 3 will be developed from the south to the north. The southern portion of both zones will be supplied intake air from the North Ramp, the central portion of the Panel 3 will be supplied from Intake Shaft 1 and the northern portion from Intake Shaft 2. The southern portion of the west zone will exhaust to the Exhaust Raise 1 in Panel 1, the central portion will exhaust to Exhaust Shaft 1 and the northern portion will exhaust to Exhaust Shaft 2. The east zone will exhaust the southern portion through Exhaust Raise 2 and the northern portion will exhaust to the Exhaust Shaft 2. During construction of the North Construction Ramp, Panel 3 and the northern portion of Panel 4, Exhaust Shaft 2 will be used as an intake shaft to help minimize safety concerns such as dust problems. Exhaust Shaft 2 will be connected to the intake main by a small access drift, since this drift is only required for construction, and does not handle large airflow volumes, it is sized smaller (5 m x 5 m, or 16 ft x 16 ft) than the regular shaft access drifts. Exhaust Shaft 2 also has the potential to be used for muck handling if so required. Exhaust Shaft 2 will be positioned to reduce overall lengths of dead end headings that are required to be constructed. Both the North Construction Ramp and the exhaust main can be connected into Exhaust Shaft 2 as they are being constructed, allowing for flow through ventilation.

The emplacement drift turnover sequence will start at the south and progress to the north. The size of turnover packages will depend on the amount of initial development that is completed before initial turnover. Initial construction access for Panel 3 will be from the North Construction Ramp. The overall drainage pattern for Panel 3 is that everything will drain to Exhaust Shaft 2. Also once Panel 3 and Panel 1 are connected at Exhaust Raise 1, Panel 1 will also be able to drain to Exhaust Shaft 2.

The exhaust main (heading 3, figure 8) can be driven from the connection with Panel 2 and underneath the North Construction Ramp as shown in Figure 8 or it can be driven in two parts from the North Construction Ramp. This would depend on the sequence of the panels. The overall amount of drift would remain the same in both cases, only the location of the shaft accesses and the grade of the main would change. Once the construction and emplacement sequence is developed, the layout of this area can be finalized.

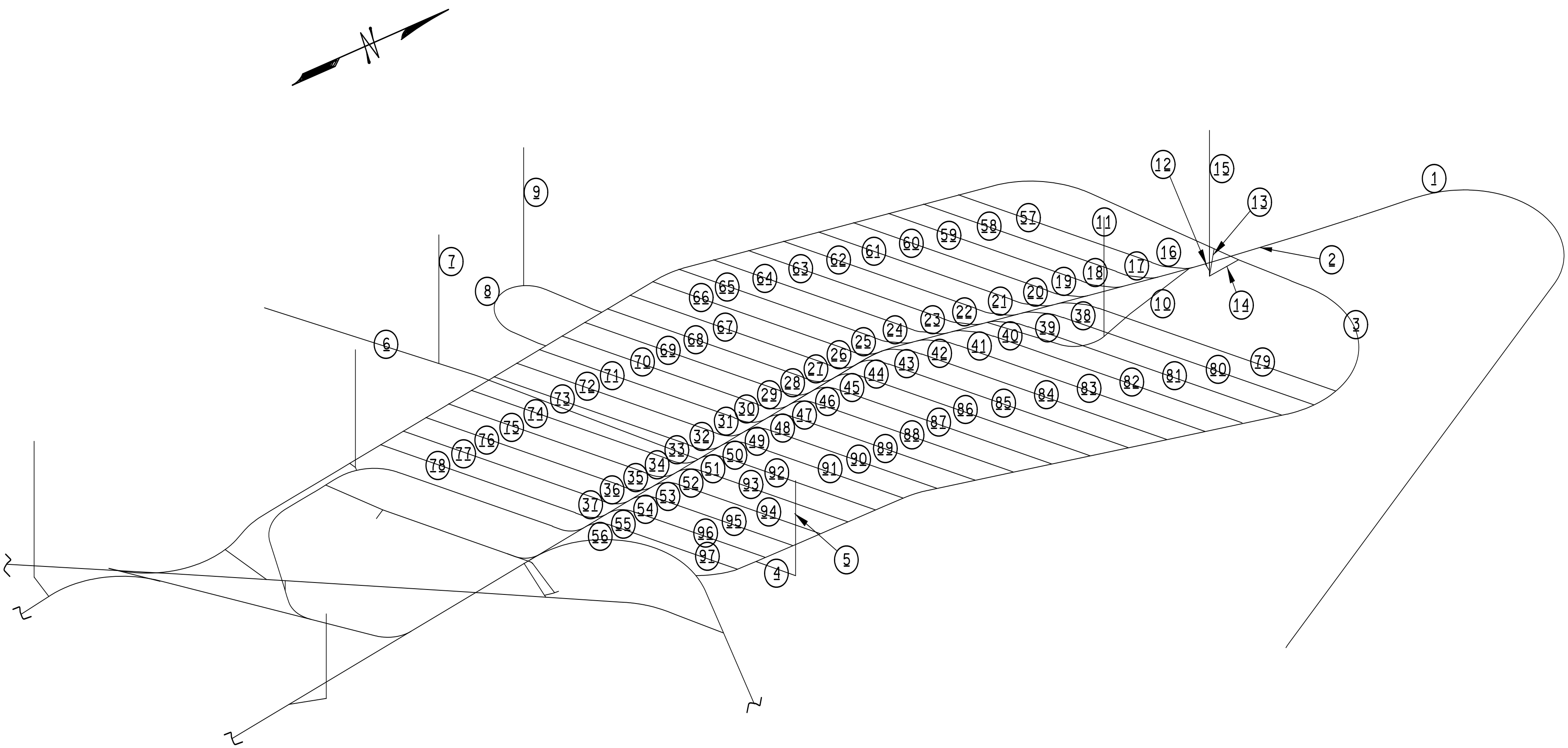


Figure 8. Panel 3

* Note: Numbers refer to the headings in Table 5

Table 5. Panel 3 Opening Sizes and Lengths

Heading		Size		Plan Length	
		meters	feet	meters	feet
1	North Construction Ramp	7.62 diameter	25 diameter	2884	9462
2	Intake Main	7.62 diameter	25 diameter	2371	7779
3	Exhaust Main	7.62 diameter	25 diameter	5728	18793
4	Exhaust Raise # 2 Access	5 x 5	16 x 16	127	417
5	Exhaust Raise # 2	5 m diameter	16 diameter	279	915
6	Intake Shaft # 1 Access	7.62 diameter	25 diameter	1384	4541
7	Intake Shaft # 1	8 diameter	26 diameter	378	1240
8	Exhaust Shaft # 1 Access	8 x 8.5	26 x 28	598	1962
9	Exhaust Shaft # 1	8 diameter	26 diameter	405	1329
10	Intake Shaft # 2 Access	8 x 8.5	26 x 28	770	2526
11	Intake Shaft # 2	8 diameter	26 diameter	350	1148
12	Exhaust Shaft # 2 Const. Access	5 x 5	16 x 16	31	102
13	Exhaust Shaft # 2 West Access	8 x 8.5	26 x 28	118	387
14	Exhaust Shaft # 2 East Access	8 x 8.5	26 x 28	106	348
15	Exhaust Shaft # 2	8 diameter	26 diameter	428	1404
16	West Drift Turnout # 1	7 x 8	23 x 26	122	400
17	West Drift Turnout # 2	7 x 8	23 x 26	122	400
18	West Drift Turnout # 3	7 x 8	23 x 26	122	400
19	West Drift Turnout # 4	7 x 8	23 x 26	122	400
20	West Drift Turnout # 5	7 x 8	23 x 26	122	400
21	West Drift Turnout # 6	7 x 8	23 x 26	122	400
22	West Drift Turnout # 7	7 x 8	23 x 26	122	400
23	West Drift Turnout # 8	7 x 8	23 x 26	122	400
24	West Drift Turnout # 9	7 x 8	23 x 26	118	387
25	West Drift Turnout # 10	7 x 8	23 x 26	96	315
26	West Drift Turnout # 11	7 x 8	23 x 26	97	318
27	West Drift Turnout # 12	7 x 8	23 x 26	97	318
28	West Drift Turnout # 13	7 x 8	23 x 26	97	318
29	West Drift Turnout # 14	7 x 8	23 x 26	97	318
30	West Drift Turnout # 15	7 x 8	23 x 26	97	318
31	West Drift Turnout # 16	7 x 8	23 x 26	97	318
32	West Drift Turnout # 17	7 x 8	23 x 26	97	318
33	West Drift Turnout # 18	7 x 8	23 x 26	97	318
34	West Drift Turnout # 19	7 x 8	23 x 26	97	318
35	West Drift Turnout # 20	7 x 8	23 x 26	97	318
36	West Drift Turnout # 21	7 x 8	23 x 26	97	318
37	West Drift Turnout # 22	7 x 8	23 x 26	97	318
38	East Drift Turnout # 1	7 x 8	23 x 26	123	404
39	East Drift Turnout # 2	7 x 8	23 x 26	123	404
40	East Drift Turnout # 3	7 x 8	23 x 26	123	404
41	East Drift Turnout # 4	7 x 8	23 x 26	123	404
42	East Drift Turnout # 5	7 x 8	23 x 26	123	404
43	East Drift Turnout # 6	7 x 8	23 x 26	120	394
44	East Drift Turnout # 7	7 x 8	23 x 26	97	318
45	East Drift Turnout # 8	7 x 8	23 x 26	97	318
46	East Drift Turnout # 9	7 x 8	23 x 26	97	318
47	East Drift Turnout # 10	7 x 8	23 x 26	97	318
48	East Drift Turnout # 11	7 x 8	23 x 26	97	318
49	East Drift Turnout # 12	7 x 8	23 x 26	97	318
50	East Drift Turnout # 13	7 x 8	23 x 26	97	318
51	East Drift Turnout # 14	7 x 8	23 x 26	97	318
52	East Drift Turnout # 15	7 x 8	23 x 26	97	318
53	East Drift Turnout # 16	7 x 8	23 x 26	97	318
54	East Drift Turnout # 17	7 x 8	23 x 26	97	318
55	East Drift Turnout # 18	7 x 8	23 x 26	97	318

Heading		Size		Plan Length	
		meters	feet	meters	feet
56	East Drift Turnout # 19	7 x 8	23 x 26	97	318
57	West Drift # 1	5.5 diameter	18 diameter	617	2024
58	West Drift # 2	5.5 diameter	18 diameter	617	2024
59	West Drift # 3	5.5 diameter	18 diameter	617	2024
60	West Drift # 4	5.5 diameter	18 diameter	617	2024
61	West Drift # 5	5.5 diameter	18 diameter	617	2024
62	West Drift # 6	5.5 diameter	18 diameter	617	2024
63	West Drift # 7	5.5 diameter	18 diameter	617	2024
64	West Drift # 8	5.5 diameter	18 diameter	617	2024
65	West Drift # 9	5.5 diameter	18 diameter	620	2034
66	West Drift # 10	5.5 diameter	18 diameter	623	2044
67	West Drift # 11	5.5 diameter	18 diameter	622	2041
68	West Drift # 12	5.5 diameter	18 diameter	622	2041
69	West Drift # 13	5.5 diameter	18 diameter	622	2041
70	West Drift # 14	5.5 diameter	18 diameter	622	2041
71	West Drift # 15	5.5 diameter	18 diameter	622	2041
72	West Drift # 16	5.5 diameter	18 diameter	622	2041
73	West Drift # 17	5.5 diameter	18 diameter	622	2041
74	West Drift # 18	5.5 diameter	18 diameter	622	2041
75	West Drift # 19	5.5 diameter	18 diameter	622	2041
76	West Drift # 20	5.5 diameter	18 diameter	622	2041
77	West Drift # 21	5.5 diameter	18 diameter	622	2041
78	West Drift # 22	5.5 diameter	18 diameter	622	2041
79	East Drift # 1	5.5 diameter	18 diameter	757	2484
80	East Drift # 2	5.5 diameter	18 diameter	799	2621
81	East Drift # 3	5.5 diameter	18 diameter	808	2651
82	East Drift # 4	5.5 diameter	18 diameter	794	2605
83	East Drift # 5	5.5 diameter	18 diameter	787	2582
84	East Drift # 6	5.5 diameter	18 diameter	782	2566
85	East Drift # 7	5.5 diameter	18 diameter	764	2507
86	East Drift # 8	5.5 diameter	18 diameter	714	2343
87	East Drift # 9	5.5 diameter	18 diameter	664	2178
88	East Drift # 10	5.5 diameter	18 diameter	615	2018
89	East Drift # 11	5.5 diameter	18 diameter	565	1854
90	East Drift # 12	5.5 diameter	18 diameter	515	1690
91	East Drift # 13	5.5 diameter	18 diameter	479	1572
92	East Drift # 14	5.5 diameter	18 diameter	464	1522
93	East Drift # 15	5.5 diameter	18 diameter	448	1470
94	East Drift # 16	5.5 diameter	18 diameter	432	1417
95	East Drift # 17	5.5 diameter	18 diameter	417	1368
96	East Drift # 18	5.5 diameter	18 diameter	401	1316
97	East Drift # 19	5.5 diameter	18 diameter	385	1263

8.4.4 Panel 4

For Panel 4, Figure 9 shows the various openings that will be constructed. Table 6 lists the actual sizes and lengths of these openings (lengths have been rounded to the nearest meter) along centerline.

Panel 4 is developed in the primary area of the RHH to the western limit of the repository footprint area (Figure 5). The northern portion of Panel 4 shares a common exhaust main with Panel 3 and would be constructed and turned over simultaneously with the northern portion of Panel 3. The common exhaust was developed to minimize excavation, but, if required, Panel 3 and 4 can be developed and turned over independently by constructing two exhaust mains on the north end of the panel.

Panel 4 consists of 30 emplacement drifts (Figure 9) with a total useable waste emplacement length of 17,003 meters (55,783 feet). Details of the actual length of emplacement drifts, useable lengths and bounding end point coordinates for Panel 4 can be found in Attachments I and III.

The emplacement area of Panel 4 will be developed from the north to the south or from south to north. Panel 4 shares common ventilation shafts with Panel 3. The intake for the northern portion of Panel 4 will be supplied from Intake Shaft 2 and the southern portion will be supplied from Intake Shaft 1. Exhaust Shaft 2 will ventilate the northern portion, Exhaust Shaft 1 will ventilate the central portion, and the ECRB Exhaust Shaft will ventilate the southern portion of Panel 4. A ventilation drift will connect the exhaust main with the ECRB. This drift will be sized 7 x 7 m. To accommodate the potential volumes, the ECRB will be to slashed to 7 x 7 m. During construction of Panel 4, Exhaust Shaft 2 will be accessed as a construction intake to help mitigate some of the safety concerns due to dust. Also if there are concerns with the overall length of the intake main for construction without flow-through ventilation, emplacement drifts can periodically be excavated across the panel to supply construction intake air.

The emplacement drift turnover sequence can start from the north or the south, as there is potential access from both directions. The overall drainage pattern for Panel 3 is from the south to the north. All of Panel 4 drains to Exhaust Shaft 2.

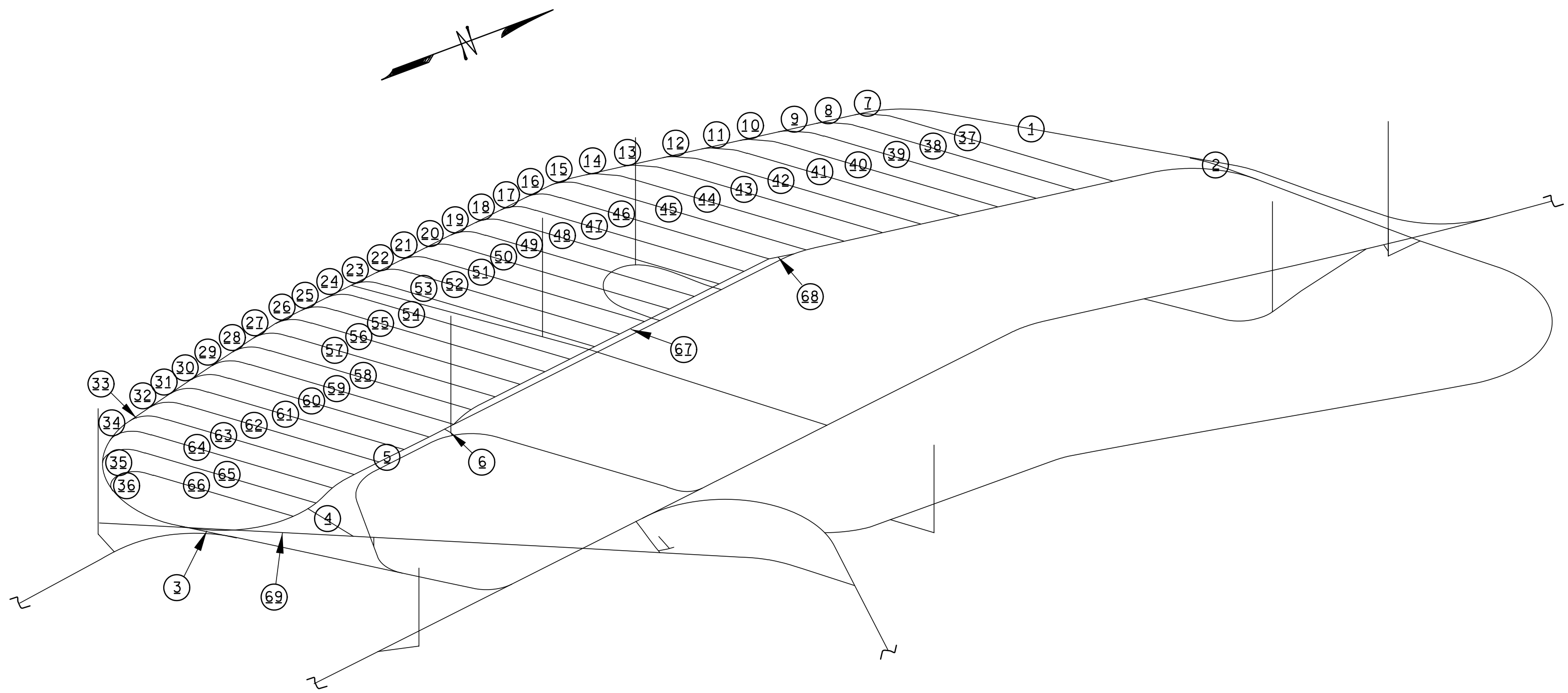


Figure 9. Panel 4

* Note: Numbers refer to the headings in Table 6

Table 6. Panel 4 Opening Sizes and Lengths

Heading		Size		Plan Length	
		meters	feet	meters	feet
1	Intake Main	7.62 diameter	25 diameter	4742	15558
2	Access to Panel 3 Exhaust	7x 7 or 7.62 diameter*	23 x 23 or 25 diameter	200	656
3	Access to Panel 2	7x 7 or 7.62 diameter*	23 x 23 or 25 diameter	155	509
4	Vent Access to ECRB	7 x 7	23 x 23	205	673
5	Southern Exhaust Main	7.62 diameter	25 diameter	907	2976
6	Access to Exhaust Raise # 1	5 x 5	16 x 16	23	75
7	Drift Turnout # 1	7 x 8	23 x 26	123	404
8	Drift Turnout # 2	7 x 8	23 x 26	123	404
9	Drift Turnout # 3	7 x 8	23 x 26	123	404
10	Drift Turnout # 4	7 x 8	23 x 26	123	404
11	Drift Turnout # 5	7 x 8	23 x 26	123	404
12	Drift Turnout # 6	7 x 8	23 x 26	123	404
13	Drift Turnout # 7	7 x 8	23 x 26	123	404
14	Drift Turnout # 8	7 x 8	23 x 26	123	404
15	Drift Turnout # 9	7 x 8	23 x 26	103	338
16	Drift Turnout # 10	7 x 8	23 x 26	97	318
17	Drift Turnout # 11	7 x 8	23 x 26	97	318
18	Drift Turnout # 12	7 x 8	23 x 26	97	318
19	Drift Turnout # 13	7 x 8	23 x 26	97	318
20	Drift Turnout # 14	7 x 8	23 x 26	97	318
21	Drift Turnout # 15	7 x 8	23 x 26	97	318
22	Drift Turnout # 16	7 x 8	23 x 26	97	318
23	Drift Turnout # 17	7 x 8	23 x 26	97	318
24	Drift Turnout # 18	7 x 8	23 x 26	97	318
25	Drift Turnout # 19	7 x 8	23 x 26	97	318
26	Drift Turnout # 20	7 x 8	23 x 26	101	331
27	Drift Turnout # 21	7 x 8	23 x 26	106	348
28	Drift Turnout # 22	7 x 8	23 x 26	106	348
29	Drift Turnout # 23	7 x 8	23 x 26	106	348
30	Drift Turnout # 24	7 x 8	23 x 26	106	348
31	Drift Turnout # 25	7 x 8	23 x 26	106	348
32	Drift Turnout # 26	7 x 8	23 x 26	106	348
33	Drift Turnout # 27	7 x 8	23 x 26	107	351
34	Drift Turnout # 28	7 x 8	23 x 26	128	420
35	Drift Turnout # 29	7 x 8	23 x 26	147	482
36	Drift Turnout # 30	7 x 8	23 x 26	175	574
37	Drift # 1	5.5 diameter	18 diameter	617	2024
38	Drift # 2	5.5 diameter	18 diameter	617	2024
39	Drift # 3	5.5 diameter	18 diameter	617	2024
40	Drift # 4	5.5 diameter	18 diameter	617	2024
41	Drift # 5	5.5 diameter	18 diameter	617	2024
42	Drift # 6	5.5 diameter	18 diameter	617	2024
43	Drift # 7	5.5 diameter	18 diameter	617	2024
44	Drift # 8	5.5 diameter	18 diameter	617	2024
45	Drift # 9	5.5 diameter	18 diameter	634	2080
46	Drift # 10	5.5 diameter	18 diameter	605	1985
47	Drift # 11	5.5 diameter	18 diameter	605	1985
48	Drift # 12	5.5 diameter	18 diameter	605	1985
49	Drift # 13	5.5 diameter	18 diameter	605	1985
50	Drift # 14	5.5 diameter	18 diameter	605	1985
51	Drift # 15	5.5 diameter	18 diameter	605	1985
52	Drift # 16	5.5 diameter	18 diameter	605	1985
53	Drift # 17	5.5 diameter	18 diameter	605	1985

Heading		Size		Plan Length	
		meters	feet	meters	feet
54	Drift # 18	5.5 diameter	18 diameter	605	1985
55	Drift # 19	5.5 diameter	18 diameter	605	1985
56	Drift # 20	5.5 diameter	18 diameter	605	1985
57	Drift # 21	5.5 diameter	18 diameter	594	1949
58	Drift # 22	5.5 diameter	18 diameter	584	1916
59	Drift # 23	5.5 diameter	18 diameter	593	1946
60	Drift # 24	5.5 diameter	18 diameter	581	1906
61	Drift # 25	5.5 diameter	18 diameter	569	1867
62	Drift # 26	5.5 diameter	18 diameter	556	1824
63	Drift # 27	5.5 diameter	18 diameter	544	1785
64	Drift # 28	5.5 diameter	18 diameter	526	1726
65	Drift # 29	5.5 diameter	18 diameter	496	1627
66	Drift # 30	5.5 diameter	18 diameter	406	1332
67	Exhaust Main (Dual with Panel 3)	7.62 diameter	25 diameter	1122	3681
68	Access to Panel 3 Exhaust	7 x 7 or 7.62 diameter*	23 x 23 or 25 diameter	70	230
69	ECRB Slash	7 x 7	23 x 23	662	2172

* The size is dependent on the construction sequence

8.5 PERFORMANCE CONFIRMATION FACILITIES

As part of performance confirmation (PC), in situ testing and monitoring will be conducted in the repository footprint. To meet these requirements, an observation drift and a test alcove off the observation drift will be located in Panel 1 (Section 5.3.1.4) The observation drift in Panel 1 (see Figure 6, heading 1) will be excavated with conventional drill and blast methods from the Thermal Testing Facility alcove (Section 5.1.2.3) underneath and to the side of the emplacement drift to the test alcove. From this location the drift will ramp up to connect with the exhaust main of Panel 1. The test alcove (see Figure 6, heading 2) will also be excavated with conventional drill and blast methods from the observation drift to a position 20 meters (66 feet) south of Emplacement Drift 3. The observation drift and alcove will both have a horseshoe profile and be sized 5 meters x 5 meters (16 feet x 16 feet). The observation drift will run parallel to Emplacement Drift 3 but will be offset to the north by 20 meters (66 feet) from the drift centerlines. The 20 meter (66 foot) offset will help maintain a stable pillar between the emplacement drift and the observation drift when the observation drift ramps up to connect with the exhaust main. Also the 20 meter (66 foot) standoff will minimize the disturbance around the emplacement while still allowing for accurate placement of the monitoring boreholes. The test alcove will be located below the emplacement drift a minimum of 10 meters (33 feet) from crown to invert in order to maintain a stable pillar.

The location of the observation drift will allow for monitoring below and to the north of Emplacement Drift 3. As the drift ramps up to connect with the exhaust main, it will also supply a platform to position boreholes to monitor above the emplacement drift. The test alcove provides monitoring coverage to the south of the emplacement drift. The combination of the test alcove and observation drift will supply coverage to nearly half the perimeter of Emplacement Drift 3 utilizing shorter than 20 meters (66 feet) boreholes.

The determining factor to use drill and blast methods to construct the observation drift was to minimize the impact on the TBM schedule, while maximizing the advance rate of this drift, however it may be decided at a later date that mechanical excavation will be used to minimize the perturbation on the host rock. The observation drift is graded away from the exhaust main to a low spot where the observation drift crosses underneath the intake main of Panel 1 (ESF), the test alcove is graded down from the south end to the intersect with the observation drift. By grading the drifts in this manner it will allow drainage away from the emplacement area.

8.6 VENTILATION INTERFACE

The overall ventilation plan is similar for each panel, or in the case where a panel is divided into zones, for each zone. The emplacement access side of the panel will be the intake side and the opposite side will only be used for exhaust. This allows for all normal operations to take place in the cooler intake air stream so no special temperature resistant equipment would be needed. The general airflow pattern will be as follows:

- The intake air will enter the repository through the ramps or intake shafts;
- Flow through the intake shaft accesses and raises to the intake/emplacement mains;
- Flow down the intake main, entering the emplacement drifts through the turnouts and the ventilation door(s);
- Flow through the emplacement drifts, exhausting to the exhaust main;
- Travel down the exhaust main to the exhaust access raises;
- Travel down to the raises to the exhaust accesses;
- Flow through the accesses to the exhaust shaft/raises; and
- Exit the repository through either a full size exhaust shaft or a smaller exhaust raise.

The exhaust system will be set up so that each emplacement drift can be isolated from the rest of the repository during off normal conditions. This will be achieved by positioning exhaust shafts or raises at the ends of each panel. The exhaust from one side of the drift requiring isolation would be diverted to the shaft or raise on that side and the exhaust from the other side would be diverted to the other shaft. This would allow off normal access to the isolated drift and the corresponding portion of the exhaust main without any potential exposure to the exhaust air. It would also allow for one or more drifts to be isolated without affecting the overall performance of the repository.

The opening sizes were maintained at similar sizes as that determined in the *Site Recommendation Subsurface Layout* (BSC 2001c, Attachment IV).

The ventilation mains, both intake and exhaust will be sized at 7.62 meter (25 foot) diameter and will be excavated with a TBM except for the exhaust main of Panel 1. As the exhaust main of Panel 1 becomes Emplacement Drift 1 and this main only has to support the exhaust of Panel 1, it will be 5.5 meter (18 foot) diameter to correspond with the other emplacement drift and minimize equipment required for initial start up.

The full size ventilation shafts, both intake and exhaust will be sized at 8 meters (26 feet), and these shafts will be developed using conventional drill and blast shaft sinking methods. In areas where the ventilation quantities do not require a full sized shaft, such as exhaust for Panel 1 and the south end of the east zone of Panel 3, exhaust raises to surface would be used. These raises will be sized at 5 meters (16 feet) and will be raise bored. These raises will be quicker and more cost effective to construct than a shaft of the same size.

The accesses to the shaft and raises will be excavated with conventional drill and blast methods. The accesses for the shafts will be sized at 8 meters x 8.5 meters (26 feet x 28 feet) and the accesses to the raises will be sized at 5 meters x 5 meters (16 feet x 16 feet). Construction vent raises that will handle low airflow volumes, such as the connection between the ECRB and the Panel 1 exhaust main will be 2 meter (7 foot) diameter and will be raise bored. To fully utilized the ECRB Shaft, the ECRB will be slashed to 7 x 7 m (23 x 23 ft) and the ventilation access to Panel 4 will also be 7 x 7 m (23 x 23 ft). The accesses will not require rail and will be driven at grades up to 15%.

The detailed ventilation volume allocation will not be determined in this calculation. The shaft and raise locations were determined based on suitable surface topography for collar locations and to approximately balance the ventilation system (i.e. balancing the number of drifts feeding into either side of a shaft).

The overall ventilation system consists of 3 shafts and 3 ramps on the intake side and 4 shafts and 2 raises on the exhaust side. These shafts and raises service 106 emplacement drifts in the four panels. Based on previous analysis (BSC 2001c) estimated intake quantities for ventilating each drift was 15 m^3/s (31,783 cfm) (BSC 2001c p. 62) and after expansion the exhaust was approximately 17 m^3/s (36,021 cfm) (BSC 2001c, p. IV-5). This configuration of intakes and exhausts will have a minimum of 20 percent extra capacity. Table 7 list the shaft collar and station coordinates and locations are shown in Figure 10.

Table 7. Shaft Locations

Shafts		Metric			Imperial		
Intakes							
		Northing	**Easting**	**Elevation**	**Northing**	**Easting**	**Elevation**
Intake Shaft 1	Collar	234474.453	170560.873	1450	769271.6	559581.8	4757.208
	Station	234474.453	170560.873	1072.017	769271.6	559581.8	3517.11
Intake Shaft 2	Collar	235903.432	171805.963	1410	773959.8	563666.7	4625.975
	Station	235903.432	171805.963	1059.535	773959.8	563666.7	3476.158
Intake Shaft 3	Collar	233260.252	171322.497	1325	765288	562080.6	4347.104
	Station	233260.252	171322.497	1076.902	765288	562080.6	3533.136
Portals							
		Northing	**Easting**	**Elevation**	**Northing**	**Easting**	**Elevation**
North Construction		235227.875	173211.391	1186.093	771743.5	568277.7	3891.373
North		233279.97	173679.768	1122.56	765352.7	569814.4	3682.932
South		230614.635	172900.776	1160.069	756608.2	567258.6	3805.993
Exhausts							
Exhaust Raise 1	Collar	234010	170690	1435	767747.8	560005.4	4707.996
	Station	234010	170690	1064.094	767747.8	560005.4	3491.116
Exhaust Raise 2	Collar	234580	171890	1340	769617.9	563942.4	4396.317
	Station	234580	171890	1061.201	769617.9	563942.4	3481.624
		Northing	**Easting**	**Elevation**	**Northing**	**Easting**	**Elevation**
Exhaust Shaft 1	Collar	234880.587	170495.703	1470	770604.1	559368	4822.825
	Station	234880.587	170495.703	1064.977	770604.1	559368	3494.012
Exhaust Shaft 2	Collar	236330.286	171803.382	1450	775360.3	563658.3	4757.208
	Station	236330.286	171803.382	1022.294	775360.3	563658.3	3353.976
Exhaust Shaft 3	Collar	230842.855	170669.239	1400	757356.9	559937.3	4593.167
	Station	230842.855	170669.239	1107.869	757356.9	559937.3	3634.734
ECRB Exhaust Shaft	Collar	233029.534	170378.507	1475	764531.1	558983.5	4839.229
	@ ECRB	233029.534	170378.507	1109.405	764531.1	558983.5	3639.773
	Station	233029.534	170378.507	1076.564	764531.1	558983.5	3532.027

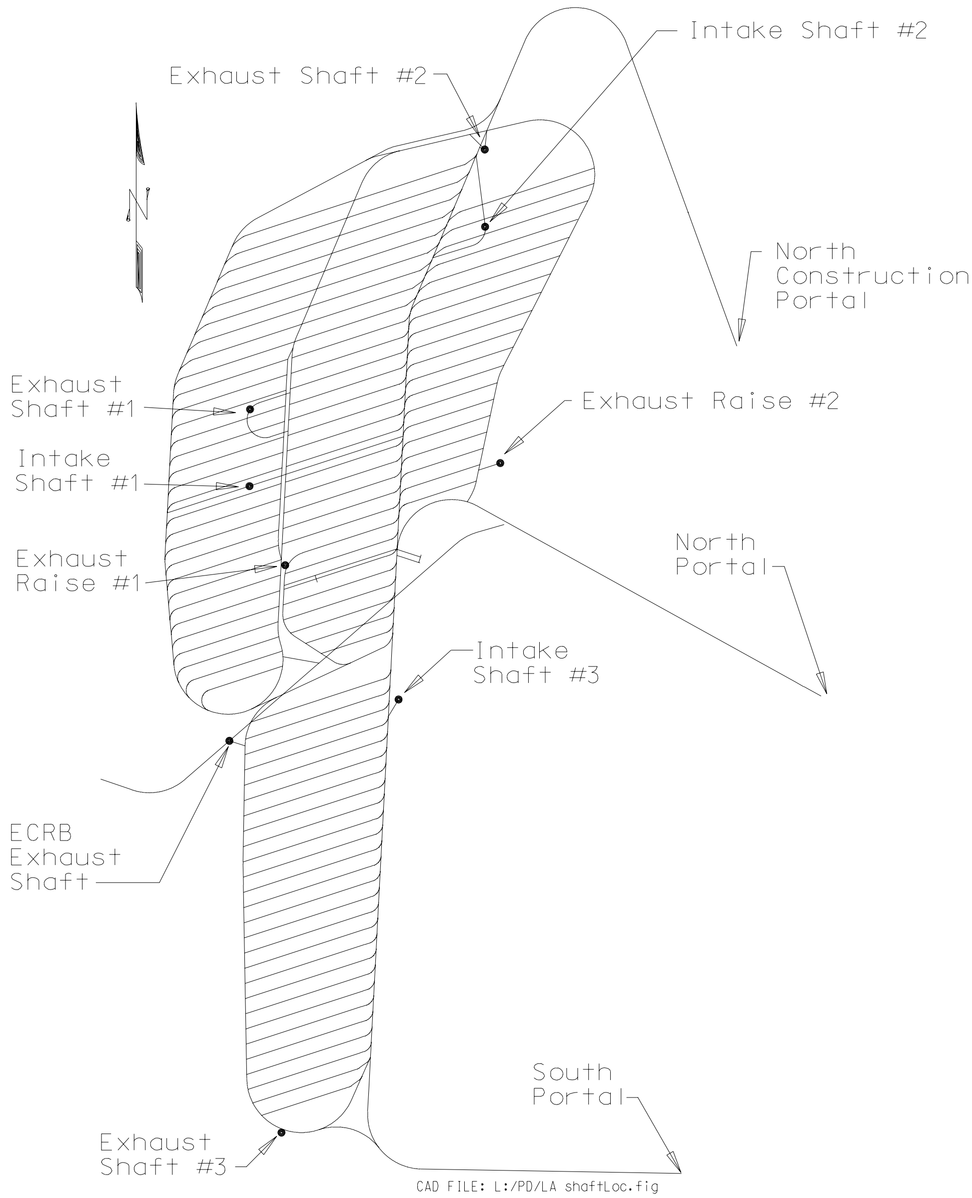


Figure 10. Shaft Locations

8.7 EXCAVATION SUMMARY

The detailed excavation lengths for the underground layout are summarized in Table 8. Table 9 through Table 12 outlines the excavation lengths associated with each emplacement panel.. The summarized lengths are from the rounded lengths in Section 8.4. Figure 11 shows there are potentially 12 assemble/disassemble chambers required for the large TBM, each of these chamber is 11 x 11m (36 x 36 ft) and 20 m long (66 ft). These excavations have been included in Table 8.

Table 8. Excavation Summary - Overall

Opening Description	Size		Plan Length	
	meters	feet	meters	feet
Emplacement Drifts	5.5 diameter	18 diameter	66,450	218,017
Emplacement Drift Turnouts	7 x 8	23 x 26	11,148	36,564
Access/Exhaust Mains	7.62 diameter	25 diameter	22,295	73,147
Exhaust Main	5.5 diameter	18 diameter	1,198	3,931
Intake/Exhaust Shafts	8 diameter	26 diameter	2,499	8,199
Shaft Access	8 x 8.5	26 x 28	1,812	5,946
Construction Shaft Access	5 x 5	16 x 16	31	102
Exhaust Raise	5 diameter	16 diameter	650	2,132
Construction Vent Raise	2 diameter	6.5 diameter	29	95
Exhaust Raise Access	5 x 5	16 x 16	163	535
Main Slash	7 x 7	23 x 23	965	3,166
Intake Main Extension	7 x7	23 x 23	258	846
Assembly/Disassembly Chambers	11 x 11	36 x 36	240	787
Ventilation Access	7 x 7	23 x 23	205	673
Intake Shaft Access	7.62 diameter	25 diameter	1,384	4,541
Performance Confirmation Facility	5 x 5	16 x 16	779	2,556
TOTAL			109,866	360,450

Table 9. Excavation Summary for Panel 1

Opening Description	Size		Plan Length	
	meters	feet	meters	feet
Emplacement Drifts	5.5 diameter	18 diameter	4,225	13,863
Emplacement Drift Turnouts	7 x 8	23 x 26	776	2,544
Access/Exhaust Mains	7.62 diameter	25 diameter	0	0
Exhaust Main	5.5 diameter	18 diameter	1,198	3,931
Intake/Exhaust Shafts	8 diameter	26 diameter	0	0
Shaft Access	8 x 8.5	26 x 28	0	0
Exhaust Raise	5 diameter	16 diameter	371	1217
Construction Vent Raise	2 diameter	6.5 diameter	29	95
Exhaust Raise Access	5 x 5	16 x 16	13	43
Intake Main Extension	7 x 7	23 x 23	258	846
Performance Confirmation Facility	5 x 5	16 x 16	779	2,556
TOTAL			7,649	25,095

Table 10. Excavation Summary for Panel 2

Opening Description	Size		Plan Length	
	meters	feet	meters	Feet
Emplacement Drifts	5.5 diameter	18 diameter	19,318	63,380
Emplacement Drift Turnouts	7 x 8	23 x 26	2,671	8,758
Access/Exhaust Mains	7.62 diameter	25 diameter	4,116	13,503
Exhaust Main	5.5 diameter	18 diameter	0	0
Intake/Exhaust Shafts	8 diameter	26 diameter	938	3,078
Shaft Access	8 x 8.5	26 x 28	220	723
Exhaust Raise	5 diameter	16 diameter	0	0
Construction Vent Raise	2 diameter	6.5 diameter	0	0
Exhaust Raise Access	5 x 5	16 x 16	0	0
Main Slash	7 x 7	23 x 23	303	994
Performance Confirmation Facility	5 x 5	16 x 16	0	0
TOTAL			27,566	90,436

Table 11. Excavation Summary for Panel 3

Opening Description	Size		Plan Length	
	meters	feet	meters	feet
Emplacement Drifts	5.5 diameter	18 diameter	25,233	82,789
Emplacement Drift Turnouts	7 x 8	23 x 26	4,350	14,266
Access/Exhaust Mains	7.62 diameter	25 diameter	10,983	36,034
Exhaust Main	5.5 diameter	18 diameter	0	0
Intake/Exhaust Shafts	8 diameter	26 diameter	1,561	5,121
Shaft Access	8 x 8.5	26 x 28	1,592	5,223
Exhaust Raise	5 diameter	16 diameter	279	915
Construction Vent Raise	2 diameter	6.5 diameter	0	0
Exhaust Raise Access	5 x 5	16 x 16	127	417
Construction Shaft Access	5 x 5	16 x 16	31	102
Shaft Access	7.62 diameter	25 diameter	1,384	4,541
Performance Confirmation Facility	5 x 5	16 x 16	0	0
TOTAL			45,540	149,408

Table 12. Excavation Summary for Panel 4

Opening Description	Size		Plan Length	
	meters	feet	meters	feet
Emplacement Drifts	5.5 diameter	18 diameter	17,674	57,985
Emplacement Drift Turnouts	7 x 8	23 x 26	3,351	10,996
Access/Exhaust Mains	7.62 diameter	25 diameter	7,196	23,610
Exhaust Main	5.5 diameter	18 diameter	0	0
Intake/Exhaust Shafts	8 diameter	26 diameter	0	0
Shaft Access	8 x 8.5	26 x 28	0	0
Exhaust Raise	5 diameter	16 diameter	0	0
Construction Vent Raise	2 diameter	6.5 diameter	0	0
Exhaust Raise Access	5 x 5	16 x 16	23	75
Main Slash	7 x 7	23 x 23	662	2,172
Ventilation Access	7 x 7	23 x 23	205	673
Performance Confirmation Facility	5 x 5	16 x 16	0	0
TOTAL			29,111	95,511

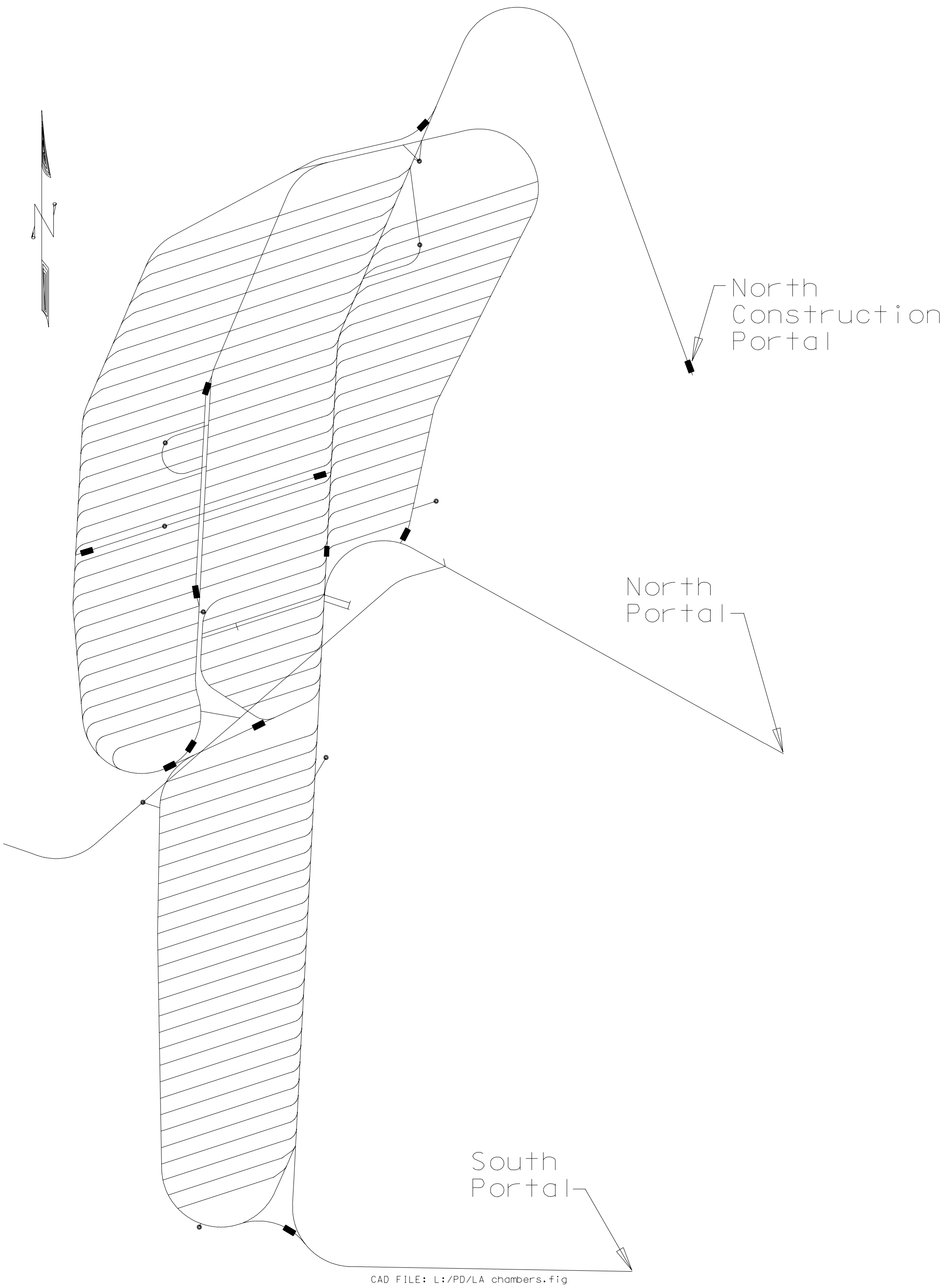


Figure 11. Potential TBM Chambers

8.8 LAYOUT FLEXIBILITY

This section outlines the design flexibility associated with the underground layout for the 70,000 MTHM case as directed by the DOE (Waisley, S. 2001). The discussion of the loading flexibility for the 70,000 MTHM case does not preclude receipt or emplacement of larger waste quantities, but it is not within the scope of this document to determine those quantities. At a 0.1 m WP spacing, the 70,000 MTHM case can be accommodated by emplacing all of Panels 1, 3, 4 and up to Drift 17 in Panel 2 (Attachment IV). This will leave 6,541.2 m of contingency in the remaining 10 drifts of Panel 2.

9. RESULTS

Sufficient capacity exists within the underground layout to support a 70,000 MTHM waste inventory (see Section 8.8).

The underground layout configuration also allows sufficient flexibility for supporting any parametric studies required for documenting a flexible-operating mode.

The underground layout can accommodate emplacement scenarios requiring up to 63.9 kilometers (39.7 miles) of emplacement drift (see Attachment IV). This relates to approximately 4.1 kilometers (2.5 miles) in Panel 1, 18.8 kilometers (11.7miles) in Panel 2, 24.0 kilometers (14.9 miles) in Panel 3, and 17.0 kilometers (10.6 miles) in Panel 4 (Attachment I). This layout configuration is contained in the output files SUBSURFACELADESIGN_M.dxf and SUBSURFACELADESIGN_I.dxf (see Attachment V).

This document should be considered in conjunction with a thermal management analysis to determine the viability of any specific combination of operating parameters.

The information generated as a result of this analysis is reasonable compared to the inputs documented in Sections 5, 6, and 7 and the calculation and underground layout, as presented in Section 8, is suitable for use as the technical basis for the underground layout general arrangement drawings. Shared interfaces are accurate and correct, and design interfaces have been considered as outlined in Section 6.4 and 6.5.

Attachment II includes miscellaneous information required for inputs to the scientific models.

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ATTACHMENT I
AVAILABLE EMPLACEMENT DRIFT LENGTH

The lengths of the emplacement drifts represented in this attachment are extracted from the SUBSURFACELADESIGN_M.dxf using VULCAN V4.0NT. These emplacement drift lengths represent the total excavated length of the emplacement drifts. SUBSURFACELADESIGN_I.dxf represents the converted layout in Imperial units

Portions of these excavated emplacement drifts will not be used for waste emplacement for a number of reasons, which are outlined below. These lengths of emplacement drift are considered unusable and will not be included in determining the capacity or flexibility of the underground layout.

Unusable emplacement drift is defined as the following:

- An operational standoff distance is maintained from the end of the each emplacement drift to the theoretical end of the closest WP. This standoff distance is 15 meters (49 feet) at the exhaust end of the emplacement drift and 1.5 meters (5 feet) at the intake end of the emplacement drift (see Section 6.3) for a total of 16.5 meters (54 feet) per emplacement drift.

- Unusable emplacement drift length accounts for emplacement area that extends beyond the footprint boundary outlined in Figure 1 (Footprint Restriction).

The available length of emplacement drift is calculated as the excavation lengths of each drift less the total standoff lengths as shown in Tables I-1 through I-4. The excavated emplacement drift lengths were extracted in SI units using VULCAN V4.0NT, then converted to Imperial units. All calculations are performed in SI units, then converted to Imperial units and rounded to the nearest 1/10th of a foot.

Table I- 1. Available Emplacement Drift Length, Panel 1

Drift	Excavated Length		Operational Standoff & Footprint Restriction		Available Drift Length		Cum. Available Drift Length	
	meters	Feet	meters	feet	meters	feet	meters	feet
1	493.963	1,620.6	16.500	54.1	477.463	1,566.5	477.463	1,566.5
2	596.051	1,955.5	16.500	54.1	579.551	1,901.4	1,057.014	3,467.9
3	597.055	1,958.8	16.500	54.1	580.555	1,904.7	1,637.569	5,372.6
4	597.055	1,958.8	16.500	54.1	580.555	1,904.7	2,218.124	7,277.3
5	590.721	1,938.1	16.500	54.1	574.221	1,883.9	2,792.345	9,161.2
6	543.725	1,783.9	16.500	54.1	527.225	1,729.7	3,319.570	10,891.0
7	451.204	1,480.3	16.500	54.1	434.704	1,426.2	3,754.274	12,317.1
8	354.518	1,163.1	16.500	54.1	338.018	1,109.0	4,092.292	13,426.1
Sub	4,224.292	13,859.2	132.000	433.1	4,092.292	13,426. 1		

Table I- 2. Available Emplacement Drift Length, Panel 2

Drift	Excavated Length		Operational Standoff & Footprint Restriction		Available Drift Length		Cum. Available Drift Length	
	meters	feet	meters	feet	meters	feet	meters	feet
1	752.741	2,469.6	16.500	54.1	736.241	2,415.5	736.241	2,415.5
2	779.342	2,556.9	16.500	54.1	762.842	2,502.8	1,499.083	4,918.2
3	778.6	2,554.5	16.500	54.1	762.100	2,500.3	2,261.183	7,418.6
4	775.397	2,543.9	16.500	54.1	758.897	2,489.8	3,020.080	9,908.4
5	772.196	2,533.4	16.500	54.1	755.696	2,479.3	3,775.776	12,387.7
6	768.993	2,522.9	16.500	54.1	752.493	2,468.8	4,528.269	14,856.5
7	765.79	2,512.4	16.500	54.1	749.290	2,458.3	5,277.559	17,314.8
8	762.588	2,501.9	16.500	54.1	746.088	2,447.8	6,023.647	19,762.6
9	759.385	2,491.4	16.500	54.1	742.885	2,437.3	6,766.532	22,199.9
10	756.183	2,480.9	16.500	54.1	739.683	2,426.8	7,506.215	24,626.6
11	749.854	2,460.1	16.500	54.1	733.354	2,406.0	8,239.569	27,032.7
12	743.526	2,439.4	16.500	54.1	727.026	2,385.2	8,966.595	29,417.9
13	737.196	2,418.6	16.500	54.1	720.696	2,364.5	9,687.291	31,782.4
14	730.868	2,397.9	16.500	54.1	714.368	2,343.7	10,401.659	34,126.1
15	724.539	2,377.1	16.500	54.1	708.039	2,323.0	11,109.698	36,449.1
16	718.21	2,356.3	16.500	54.1	701.710	2,302.2	11,811.408	38,751.3
17	711.881	2,335.6	16.500	54.1	695.381	2,281.4	12,506.789	41,032.7
18	705.552	2,314.8	19.049	62.5	686.503	2,252.3	13,193.292	43,285.0
19	699.223	2,294.0	22.616	74.2	676.607	2,219.8	13,869.899	45,504.8
20	692.895	2,273.3	23.434	76.9	669.461	2,196.4	14,539.360	47,701.2
21	686.565	2,252.5	21.821	71.6	664.744	2,180.9	15,204.104	49,882.1
22	680.237	2,231.7	17.676	58.0	662.561	2,173.8	15,866.665	52,055.9
23	673.908	2,211.0	16.500	54.1	657.408	2,156.8	16,524.073	54,212.7
24	667.579	2,190.2	16.500	54.1	651.079	2,136.1	17,175.152	56,348.8
25	655.358	2,150.1	16.500	54.1	638.858	2,096.0	17,814.010	58,444.8
26	583.366	1,913.9	16.500	54.1	566.866	1,859.8	18,380.876	60,304.6
27	485.213	1,591.9	16.500	54.1	468.713	1,537.8	18,849.589	61,842.4
Sub	19,317.183	63,376.5	467.596	1,534.1	18,849.589	61,842.4		

Table I- 3. Available Emplacement Drift Length, Panel 3

Drift	Excavated Length		Operational Standoff & Footprint Restriction		Available Drift Length		Cum. Available Drift	
	meters	feet	meters	feet	meters	feet	meters	Feet
W1	616.500	2,022.6	16.500	54.1	600.000	1,968.5	600.000	1,968.5
W2	616.500	2,022.6	16.500	54.1	600.000	1,968.5	1,200.000	3,937.0
W3	616.500	2,022.6	16.500	54.1	600.000	1,968.5	1,800.000	5,905.5
W4	616.500	2,022.6	16.500	54.1	600.000	1,968.5	2,400.000	7,874.0
W5	616.500	2,022.6	16.500	54.1	600.000	1,968.5	3,000.000	9,842.5
W6	616.500	2,022.6	16.500	54.1	600.000	1,968.5	3,600.000	11,811.0
W7	616.500	2,022.6	16.500	54.1	600.000	1,968.5	4,200.000	13,779.5
W8	616.500	2,022.6	16.500	54.1	600.000	1,968.5	4,800.000	15,748.0
W9	619.839	2,033.6	16.500	54.1	603.339	1,979.5	5,403.339	17,727.5
W10	622.784	2,043.3	16.500	54.1	606.284	1,989.1	6,009.623	19,716.6
W11	621.690	2,039.7	16.500	54.1	605.190	1,985.5	6,614.813	21,702.1
W12	621.690	2,039.7	16.500	54.1	605.190	1,985.5	7,220.003	23,687.6
W13	621.690	2,039.7	16.500	54.1	605.190	1,985.5	7,825.193	25,673.2
W14	621.690	2,039.7	16.500	54.1	605.190	1,985.5	8,430.383	27,658.7
W15	621.690	2,039.7	16.500	54.1	605.190	1,985.5	9,035.573	29,644.2
W16	621.690	2,039.7	16.500	54.1	605.190	1,985.5	9,640.763	31,629.7
W17	621.690	2,039.7	16.500	54.1	605.190	1,985.5	10,245.953	33,615.3
W18	621.690	2,039.7	16.500	54.1	605.190	1,985.5	10,851.143	35,600.8
W19	621.690	2,039.7	16.500	54.1	605.190	1,985.5	11,456.333	37,586.3
W20	621.690	2,039.7	16.500	54.1	605.190	1,985.5	12,061.523	39,571.8
W21	621.690	2,039.7	16.500	54.1	605.190	1,985.5	12,666.713	41,557.4
W22	621.690	2,039.7	16.500	54.1	605.190	1,985.5	13,271.903	43,542.9
E1	757.174	2,484.2	289.808	950.8	467.366	1,533.3	467.366	1,533.4
E2	798.926	2,621.1	192.237	630.7	606.689	1,990.4	1,074.055	3,523.8
E3	808.132	2,651.3	104.246	342.0	703.886	2,309.3	1,777.941	5,833.1
E4	793.966	2,604.9	16.500	54.1	777.466	2,550.7	2,555.407	8,383.9
E5	786.956	2,581.9	16.500	54.1	770.456	2,527.7	3,325.863	10,911.6
E6	781.835	2,565.1	16.500	54.1	765.335	2,510.9	4,091.198	13,422.5
E7	764.227	2,507.3	16.500	54.1	747.727	2,453.2	4,838.925	15,875.7
E8	714.319	2,343.6	16.500	54.1	697.819	2,289.4	5,536.744	18,165.1
E9	664.412	2,179.8	16.500	54.1	647.912	2,125.7	6,184.656	20,290.8
E10	614.505	2,016.1	16.500	54.1	598.005	1,962.0	6,782.661	22,252.8
E11	564.597	1,852.3	16.500	54.1	548.097	1,798.2	7,330.758	24,051.0
E12	514.691	1,688.6	16.500	54.1	498.191	1,634.5	7,828.949	25,685.5
E13	479.481	1,573.1	16.500	54.1	462.981	1,519.0	8,291.930	27,204.4
E14	463.808	1,521.7	18.648	61.2	445.160	1,460.5	8,737.090	28,664.9
E15	448.136	1,470.3	26.285	86.2	421.851	1,384.0	9,158.941	30,049.0
E16	432.463	1,418.8	17.231	56.5	415.232	1,362.3	9,574.173	31,411.3
E17	416.79	1,367.4	16.500	54.1	400.290	1,313.3	9,974.463	32,724.6
E18	401.118	1,316.0	16.500	54.1	384.618	1,261.9	10,359.081	33,986.4
E19	385.446	1,264.6	16.500	54.1	368.946	1,210.5	10,728.027	35,196.9
Sub W	13,634.903	44,733.8	363.000	1,190.9	13,271.903	43,542.9		
Sub E	11,590.982	38,028.1	862.955	2,831.2	10,728.027	35,196.9		
Sub	25,225.885	82,761.9	1,225.955	4,022.1	23,999.930	78,739.8		

Table I- 4. Available Emplacement Drift Length, Panel 4

Drift	Excavated Length		Operational Standoff & Footprint Restriction		Available Drift Length		Cum. Available Drift	
	meters	feet	meters	feet	meters	feet	meters	feet
1	616.5	2,022.6	190.059	623.6	426.441	1,399.1	426.441	1,399.1
2	616.5	2,022.6	19.407	63.7	597.093	1,959.0	1,023.534	3,358.0
3	616.5	2,022.6	16.500	54.1	600.000	1,968.5	1,623.534	5,326.5
4	616.5	2,022.6	16.500	54.1	600.000	1,968.5	2,223.534	7,295.0
5	616.5	2,022.6	16.500	54.1	600.000	1,968.5	2,823.534	9,263.5
6	616.5	2,022.6	16.500	54.1	600.000	1,968.5	3,423.534	11,232.0
7	616.5	2,022.6	16.500	54.1	600.000	1,968.5	4,023.534	13,200.5
8	616.5	2,022.6	16.500	54.1	600.000	1,968.5	4,623.534	15,169.0
9	634.452	2,081.5	16.500	54.1	617.952	2,027.4	5,241.486	17,196.4
10	605.393	1,986.2	16.500	54.1	588.893	1,932.1	5,830.379	19,128.5
11	605.393	1,986.2	16.500	54.1	588.893	1,932.1	6,419.272	21,060.6
12	605.393	1,986.2	16.500	54.1	588.893	1,932.1	7,008.165	22,992.6
13	605.393	1,986.2	16.500	54.1	588.893	1,932.1	7,597.058	24,924.7
14	605.393	1,986.2	16.500	54.1	588.893	1,932.1	8,185.951	26,856.7
15	605.393	1,986.2	16.500	54.1	588.893	1,932.1	8,774.844	28,788.8
16	605.393	1,986.2	16.500	54.1	588.893	1,932.1	9,363.737	30,720.9
17	605.393	1,986.2	16.500	54.1	588.893	1,932.1	9,952.630	32,652.9
18	605.393	1,986.2	16.500	54.1	588.893	1,932.1	10,541.523	34,585.0
19	605.393	1,986.2	16.500	54.1	588.893	1,932.1	11,130.416	36,517.0
20	605.001	1,984.9	16.500	54.1	588.501	1,930.8	11,718.917	38,447.8
21	593.519	1,947.2	16.500	54.1	577.019	1,893.1	12,295.936	40,340.9
22	583.98	1,915.9	16.500	54.1	567.480	1,861.8	12,863.416	42,202.7
23	593.37	1,946.7	16.500	54.1	576.870	1,892.6	13,440.286	44,095.3
24	580.977	1,906.1	16.500	54.1	564.477	1,852.0	14,004.763	45,947.3
25	568.584	1,865.4	16.500	54.1	552.084	1,811.3	14,556.847	47,758.6
26	556.192	1,824.8	16.500	54.1	539.692	1,770.6	15,096.539	49,529.2
27	543.788	1,784.1	16.500	54.1	527.288	1,729.9	15,623.827	51,259.2
28	526.088	1,726.0	16.500	54.1	509.588	1,671.9	16,133.415	52,931.0
29	495.837	1,626.8	16.500	54.1	479.337	1,572.6	16,612.752	54,503.7
30	406.369	1,333.2	16.500	54.1	389.869	1,279.1	17,002.621	55,782.8
Sub	17,674.087	57,985.7	671.466	2,203.0	17,002.621	55,782.8		

ATTACHMENT II
REPOSITORY AREAS

The VULCAN V4.0NT software program provides a three dimensional design of the underground layout configuration. The following areas were generated in VULCAN V4.0NT and are within the bounds of its qualifications. The files of the areas can be found in Attachment V, the geological units areas were determined using the triangulation files (TpXXX.00t files), the repository areas and fault traces are found in the DXF files (SUBSURFACELADESIGN_I.dxf, SUBSURFACELADESIGN_M.dxf and FAULTTRACE.dxf). The units in Tables II-1 and II-2 are rounded to the nearest number. The areas are shown in Figure II-1, the geological units are shown in Figure II-2 and the trace of the faults in the emplacement areas are shown in Figure II-3

The approximate thickness of the PTn can be found by contouring the file "PTnThickness.00t" (Attachment V) in VULCAN V4.0NT. There are nine different units in the PTn. This file is the difference in elevation between the 9th unit of the PTn (Topopah Spring Tuff moderately welded subzone) and the 1st unit (Tiva Canyon Tuff moderately welded subzone). The minimum thickness over the emplacement area is >20 m. There appears to be "holes" in this triangulation. These are created where the 1st or 9th units are absent. Cutting a thickness between the 7th units of the PTn (Pah Canyon bedded Tuff) and the 9th unit shows (as shown in file "PtnThickness3.00t") that the PTn thickness exceeds 10 m, thus meeting the thickness constraint.

Figure II-4 shows the boreholes that are within 50 m elevation of the plane of the repository and are reasonably close to the footprint. Also boreholes G-2, WT-6 and WT-24, which help define the watertable in the north, have been included. In total, 33 boreholes have been located. UZ-1 is the closest borehole to intersecting an emplacement drift, it is approximately 3 m from the springline. These boreholes are extracted from the Vulcan GFM 3.1 representation (MO003MWDVUL03.002).

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Table II- 1 Repository Areas

	sq. m	sq. ft
I	509,221	5,481,182
II	509,345	5,482527
III	1,048,428	11,285,140
IV	1,108,122	11,927,680
V	724,537	7,798,822
VI	392,994	4,230,135
VII	1,126,427	12,124,713
VIII	585,000	6,296,860

Table II- 2 Emplacement Areas by Geological Unit (sq. m).

	Panel						
Geological Unit	1	2	2 Cont.	3 East	3 West	4	Total
Tptpul	0	0	0	224,398	0	0	224,398
Tptpmn	119,172	79,277	936	338,409	78,209	0	616,003
Tptpll	179,678	902,050	439,097	273,002	948,118	1,271,323	4,013,268
Tptpln	0	1,208	55,299	0	0	72,976	129,483
Total	298,850	982,535	495,332	835,809	1,026,327	1,344,299	4,983,152

Table II- 3 Fault Intersect Coordinate (with Emplacement Drift invert) (m.)

Sever Wash Fault			
Drift	Northing	Easting	Elevation
3-2 E	236,080.804	172,228.178	1,043.507
3-3 E	236,012.895	172,281.310	1,044.678

Drill Hole Wash Fault			
Drift	Northing	Easting	Elevation
4-1	235,989.651	170,899.141	1,038.822
4-2	235,919.182	170,944.386	1,039.993
3-4 W	235,779.565	171,038.935	1,042.336
3-5 W	235,711.013	171,090.078	1,043.507
3-6 W	235,642.550	171,141.491	1,044.678
3-7 W	235,574.216	171,193.302	1,045.850
3-8 W	235,505.827	171,244.947	1,047.021
3-9 W	235,437.148	171,295.697	1,048.192
3-10 E	235,152.792	171,469.032	1,052.877
3-11 E	235,079.577	171,505.820	1,054.049
3-12 E	235,006.192	171,542.090	1,055.220
3-13 E	234,932.807	171,578.361	1,056.391
3-14 E	234,859.514	171,614.907	1,057.563
3-15 E	234,786.234	171,651.497	1,058.734
3-16 E	234,713.264	171,689.042	1,059.905
3-17 E	234,640.579	171,727.462	1,061.077

Pagany Wash Fault			
Drift	Northing	Easting	Elevation
3-1 W	236,217.888	171,601.585	1,038.822
3-1 E	236,013.508	171,758.938	1,042.336
3-2 E	235,945.075	171,810.448	1,043.507
3-3 E	235,876.446	171,861.351	1,044.678
3-4 E	235,807.771	171,912.113	1,045.850
3-5 E	235,738.490	171,961.013	1,047.021
3-6 E	235,669.240	172,010.006	1,048.192
3-7 E	235,599.953	172,058.886	1,049.363

West Ghost Dance Fault			
Drift	Northing	Easting	Elevation
2-17	231,868.412	170,797.192	1,095.046
2-18	231,780.447	170,788.587	1,096.218
2-19	231,691.954	170,778.356	1,097.389
2-20	231,603.653	170,768.718	1,098.560
2-21	231,515.406	170,759.244	1,099.732
2-22	231,427.566	170,751.025	1,100.903
2-23	231,340.690	170,745.771	1,102.074
2-24	231,258.288	170,754.288	1,103.246
2-25	231,176.124	170,763.537	1,104.417
2-26	231,093.364	170,770.950	1,105.589
2-27	231,009.562	170,775.160	1,106.760

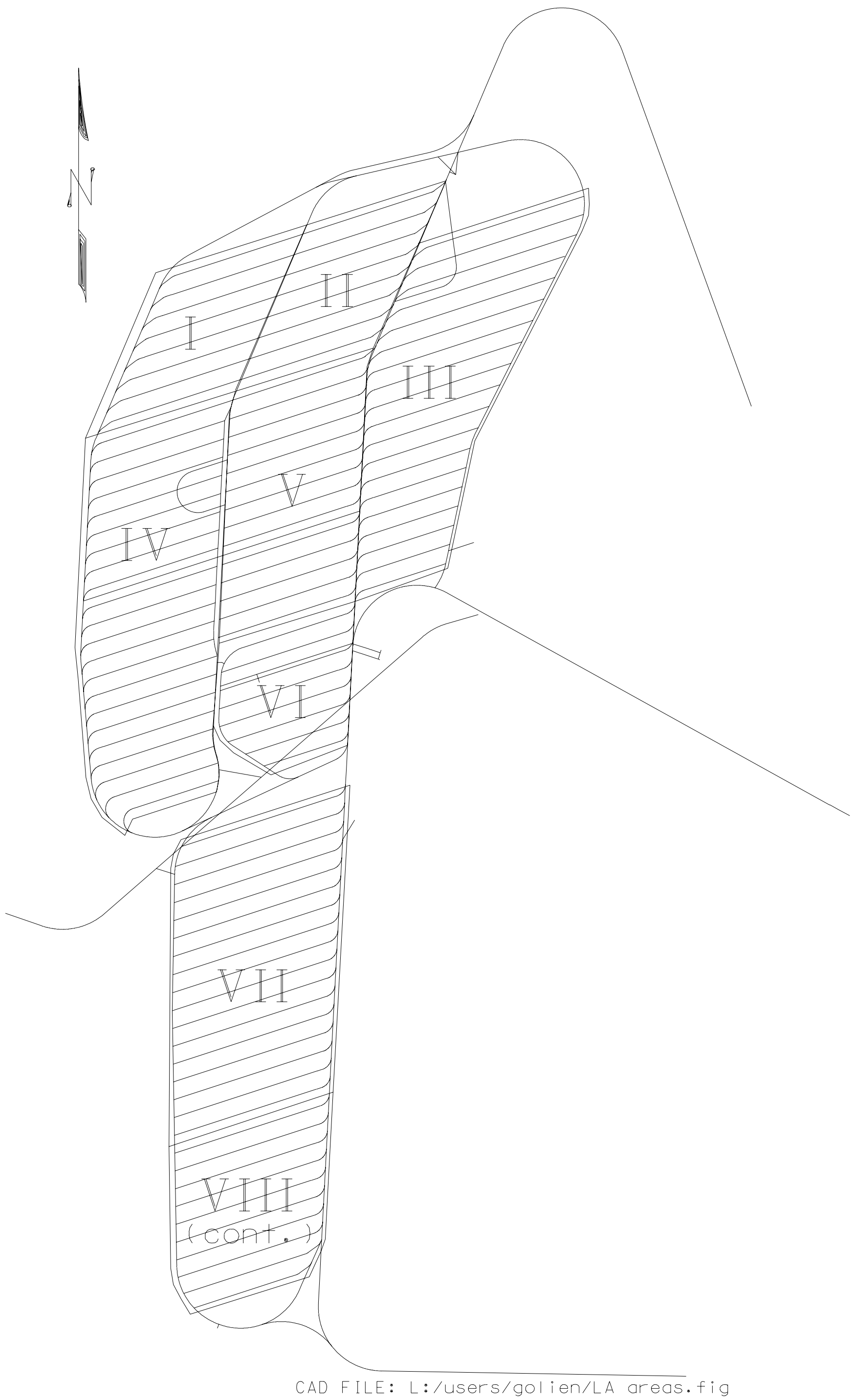

Figure II- 1. Areas

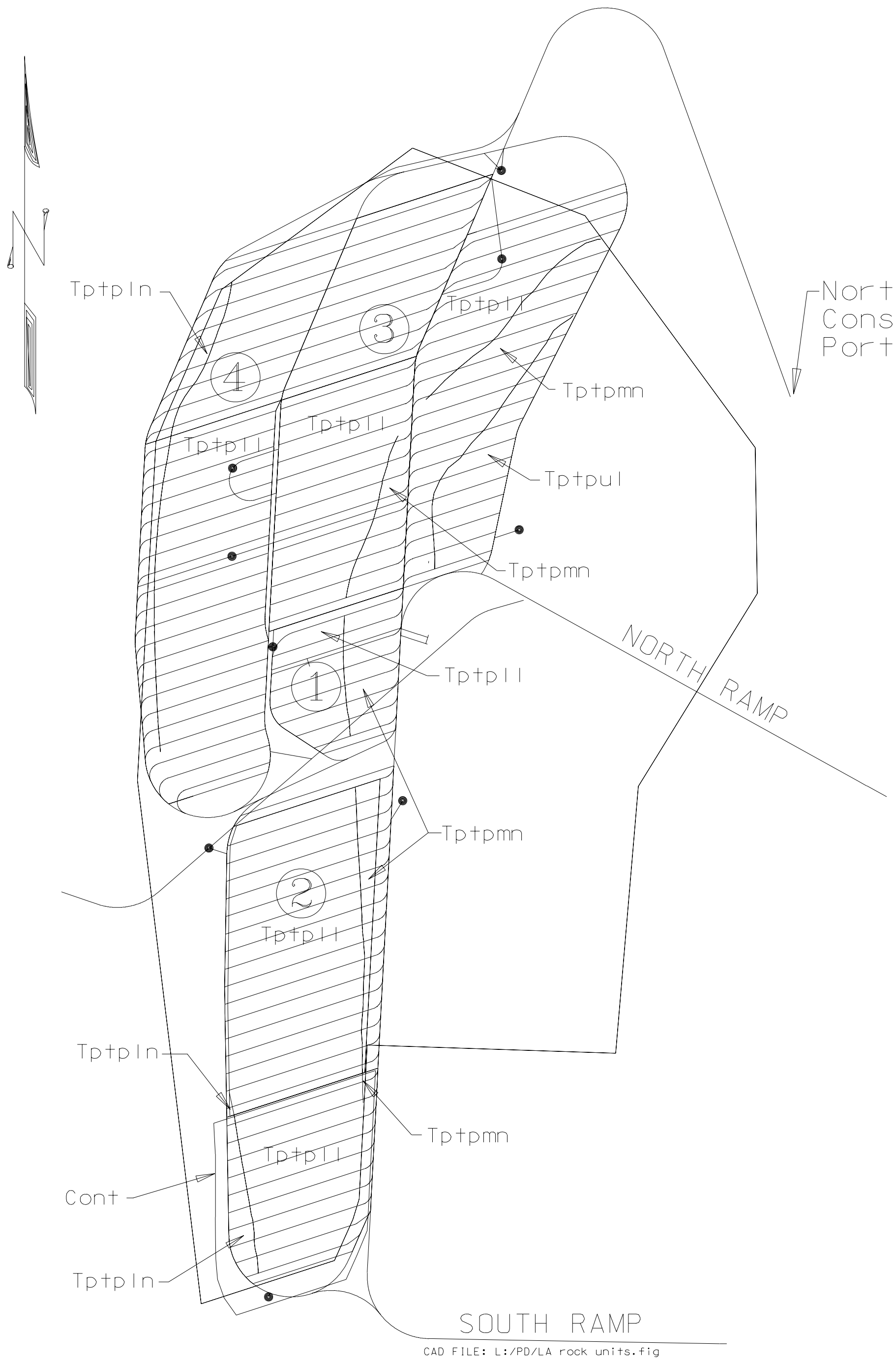

Figure II-2. Geological Units by Panel

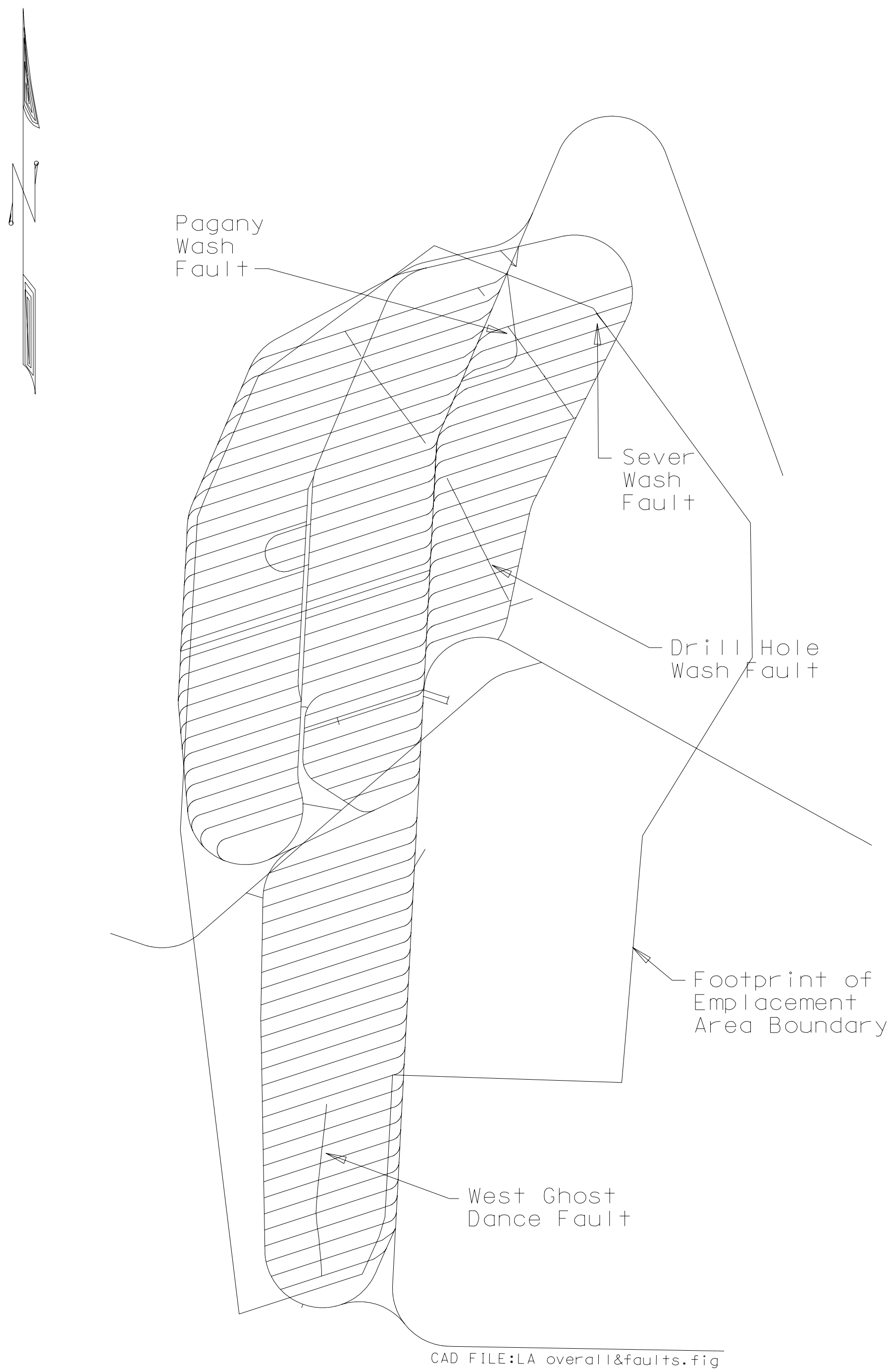

Figure II-3. Fault Traces in the Emplacement Areas

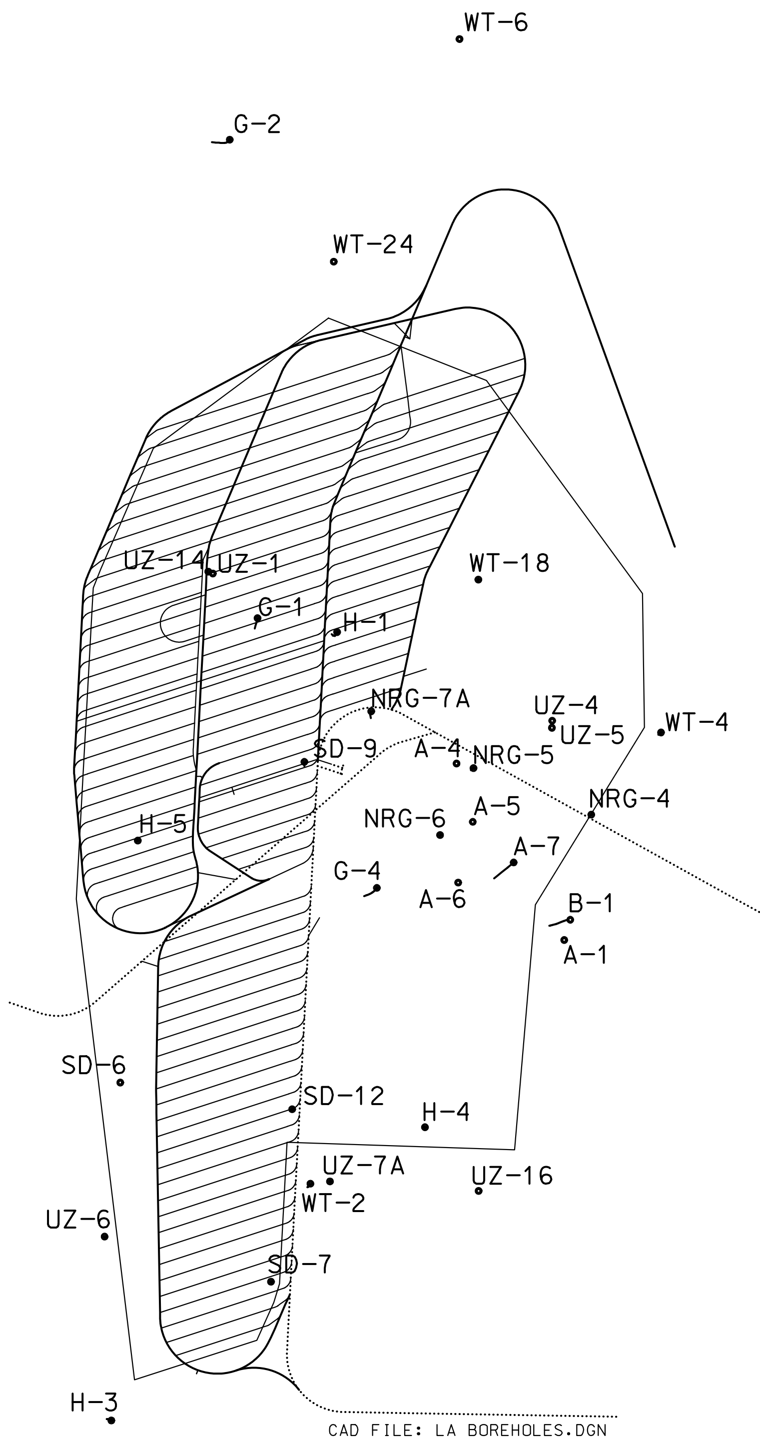

Figure II-4. Boreholes

ATTACHMENT III
BOUNDING ENDPOINT COORDINATES FOR EMPLACEMENT DRIFTS

The emplacement area in the underground layout is bounded by a set of coordinates that represent the theoretically last emplaced WP in the drift. Emplaced WPs on either end of the emplacement drift will be placed a minimum of 1.5 meters (5 feet) from the end of emplacement drift turnout interface and a minimum of 15 meters (49 feet) from centerline of the exhaust main (Section 6.3).

The endpoint coordinates are Nevada State Plane Coordinate System, NAD 27 represented in both SI and Imperial units. The endpoint coordinates were extracted in SI units using VULCAN V4.0NT, then converted to Imperial units.

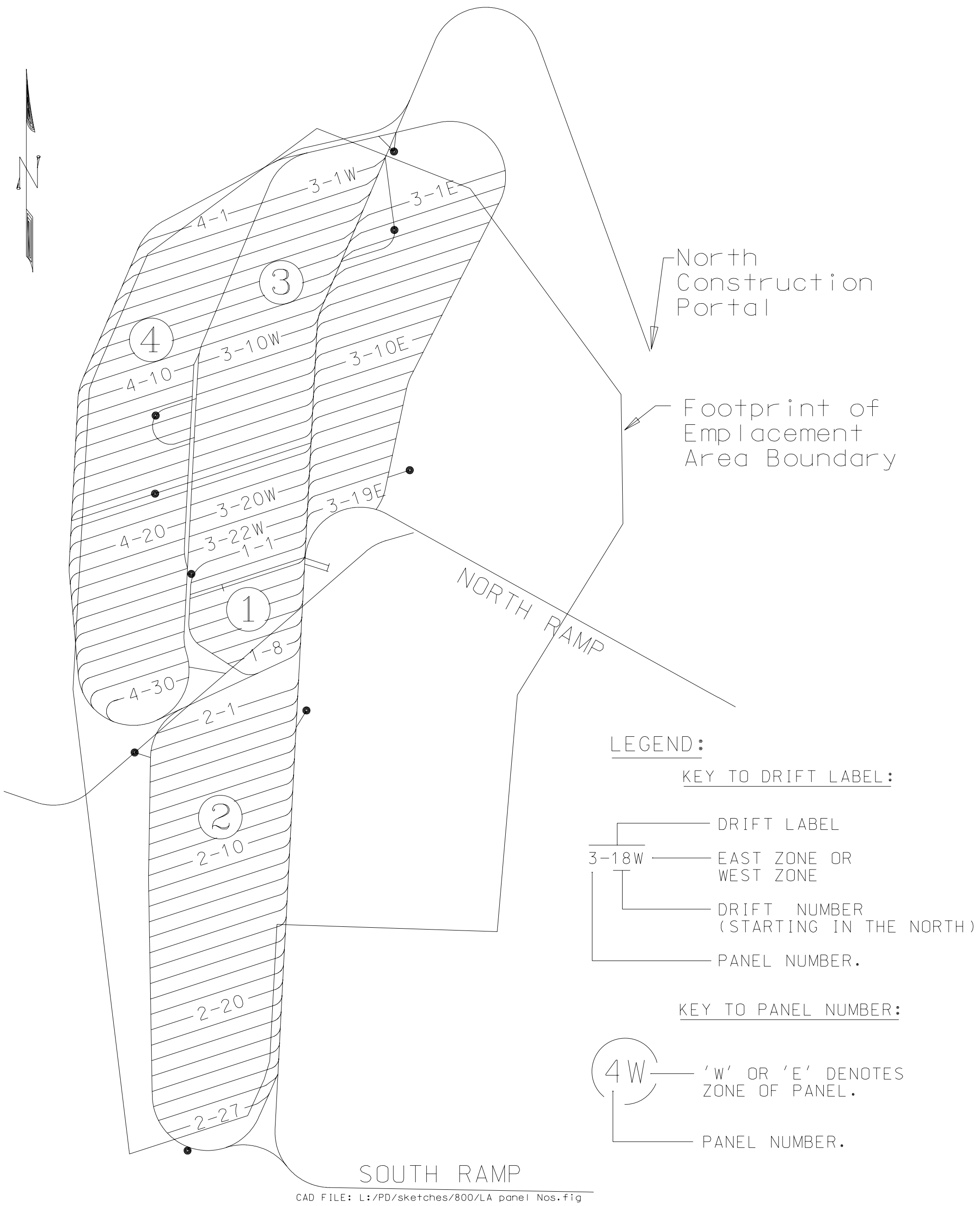

Figure III- 1. Bounding Endpoint Coordinates

Table III- 1. Primary Area Bounding Endpoint Coordinates, Panels 1, 2, 3, and 4

Label	Northing		Easting		Elevation		Panel	Drift	Zone	Side
	meters	feet	meters	feet	meters	feet				
1-1	234232.646	768478.27	171258.34	561870.07	1064.59	3492.74	1	1		East
	234085.101	767994.20	170804.246	560380.26	1064.59	3492.74	1	1		West
1-2	234146	768194.00	171253.799	561855.17	1065.762	3496.59	1	2		East
	233966.91	767606.44	170702.613	560046.82	1065.762	3496.59	1	2		West
1-3	234059.357	767909.74	171249.258	561840.27	1066.933	3500.43	1	3		East
	233879.956	767321.16	170697.118	560028.79	1066.933	3500.43	1	3		West
1-4	233972.714	767625.48	171244.717	561825.38	1068.105	3504.27	1	4		East
	233793.312	767036.89	170692.577	560013.90	1068.105	3504.27	1	4		West
1-5	233886.07	767341.21	171240.176	561810.48	1069.276	3508.12	1	5		East
	233708.625	766759.05	170694.06	560018.76	1069.276	3508.12	1	5		West
1-6	233799.426	767056.95	171235.636	561795.58	1070.447	3511.96	1	6		East
	233636.504	766522.43	170734.215	560150.50	1070.447	3511.96	1	6		West
1-7	233712.783	766772.69	171231.095	561780.68	1071.618	3515.80	1	7		East
	233578.451	766331.97	170817.667	560424.30	1071.618	3515.80	1	7		West
1-8	233626.138	766488.42	171226.554	561765.79	1072.79	3519.65	1	8		East
	233521.685	766145.73	170905.08	560711.08	1072.79	3519.65	1	8		West
3- 1E	235992.979	774253.63	171695.756	563305.16	1042.336	3419.73	3	1	East	West
	236137.403	774727.46	172140.248	564763.46	1042.336	3419.73	3	1	East	East
3- 2E	235894.184	773929.50	171653.82	563167.57	1043.507	3423.57	3	2	East	West
	236081.661	774544.58	172230.815	565060.60	1043.507	3423.57	3	2	East	East
3- 3E	235795.39	773605.38	171611.884	563029.99	1044.678	3427.41	3	3	East	West
	236012.902	774319.00	172281.32	565226.30	1044.678	3427.41	3	3	East	East
3- 4E	235696.595	773281.25	171569.949	562892.41	1045.85	3431.26	3	4	East	West
	235936.845	774069.47	172309.363	565318.30	1045.85	3431.26	3	4	East	East
3- 5E	235597.8	772957.12	171528.013	562754.82	1047.021	3435.10	3	5	East	West
	235835.884	773738.23	172260.76	565158.84	1047.021	3435.10	3	5	East	East
3- 6E	235497.316	772627.44	171480.877	562600.18	1048.192	3438.94	3	6	East	West
	235733.817	773403.36	172208.754	564988.22	1048.192	3438.94	3	6	East	East
3- 7E	235400.691	772310.43	171445.618	562484.50	1049.363	3442.79	3	7	East	West
	235631.751	773068.50	172156.749	564817.60	1049.363	3442.79	3	7	East	East
3- 8E	235314.047	772026.17	171441.077	562469.60	1050.535	3446.63	3	8	East	West
	235529.684	772733.64	172104.743	564646.98	1050.535	3446.63	3	8	East	East
3- 9E	235227.403	771741.90	171436.537	562454.71	1051.706	3450.47	3	9	East	West
	235427.618	772398.78	172052.738	564476.36	1051.706	3450.47	3	9	East	East
3- 10E	235140.759	771457.64	171431.996	562439.81	1052.877	3454.31	3	10	East	West
	235325.552	772063.92	172000.733	564305.74	1052.877	3454.31	3	10	East	East
3- 11E	235054.115	771173.38	171427.455	562424.91	1054.049	3458.16	3	11	East	West
	235223.485	771729.05	171948.727	564135.12	1054.049	3458.16	3	11	East	East

Label	Northing		Easting		Elevation		Panel	Drift	Zone	Side
	meters	feet	meters	feet	meters	feet				
3- 12E	234967.47	770889.11	171422.914	562410.01	1055.22	3462.00	3	12	East	West
	235121.419	771394.19	171896.722	563964.50	1055.22	3462.00	3	12	East	East
3- 13E	234880.826	770604.84	171418.373	562395.11	1056.391	3465.84	3	13	East	West
	235023.895	771074.23	171858.695	563839.74	1056.391	3465.84	3	13	East	East
3- 14E	234794.182	770320.58	171413.833	562380.22	1057.563	3469.69	3	14	East	West
	234931.743	770771.89	171837.205	563769.23	1057.563	3469.69	3	14	East	East
3- 15E	234707.537	770036.31	171409.292	562365.32	1058.734	3473.53	3	15	East	West
	234837.896	770464.00	171810.496	563681.60	1058.734	3473.53	3	15	East	East
3- 16E	234620.893	769752.05	171404.751	562350.42	1059.905	3477.37	3	16	East	West
	234749.206	770173.02	171799.66	563646.05	1059.905	3477.37	3	16	East	East
3- 17E	234534.249	769467.78	171400.21	562335.52	1061.077	3481.22	3	17	East	West
	234657.945	769873.61	171780.909	563584.53	1061.077	3481.22	3	17	East	East
3- 18E	234447.604	769183.51	171395.67	562320.63	1062.248	3485.06	3	18	East	West
	234566.457	769573.45	171761.463	563520.73	1062.248	3485.06	3	18	East	East
3- 19E	234360.96	768899.25	171391.129	562305.73	1063.419	3488.90	3	19	East	West
	234474.97	769273.30	171742.017	563456.93	1063.419	3488.90	3	19	East	East
3- 1W	236237.413	775055.58	171661.675	563193.35	1038.822	3408.20	3	1	West	East
	236052.003	774447.28	171091.041	561321.19	1038.822	3408.20	3	1	West	West
3- 2W	236138.618	774731.45	171619.739	563055.76	1039.993	3412.04	3	2	West	East
	235953.208	774123.15	171049.105	561183.61	1039.993	3412.04	3	2	West	West
3- 3W	236039.823	774407.32	171577.803	562918.18	1041.164	3415.89	3	3	West	East
	235854.413	773799.02	171007.169	561046.02	1041.164	3415.89	3	3	West	West
3- 4W	235941.028	774083.19	171535.867	562780.59	1042.336	3419.73	3	4	West	East
	235755.618	773474.89	170965.233	560908.44	1042.336	3419.73	3	4	West	West
3- 5W	235842.233	773759.06	171493.931	562643.01	1043.507	3423.57	3	5	West	East
	235656.823	773150.76	170923.297	560770.85	1043.507	3423.57	3	5	West	West
3- 6W	235743.438	773434.93	171451.995	562505.42	1044.678	3427.41	3	6	West	East
	235558.029	772826.63	170881.361	560633.27	1044.678	3427.41	3	6	West	West
3- 7W	235644.644	773110.80	171410.059	562367.84	1045.85	3431.26	3	7	West	East
	235459.234	772502.50	170839.425	560495.68	1045.85	3431.26	3	7	West	West
3- 8W	235545.849	772786.67	171368.123	562230.25	1047.021	3435.10	3	8	West	East
	235360.439	772178.37	170797.489	560358.10	1047.021	3435.10	3	8	west	West
3- 9W	235448.554	772467.46	171330.802	562107.81	1048.192	3438.94	3	9	West	East
	235262.112	771855.78	170756.993	560225.23	1048.192	3438.94	3	9	West	West
3- 10W	235359.359	772174.83	171318.41	562067.15	1049.363	3442.79	3	10	West	East
	235172.007	771560.16	170741.8	560175.39	1049.363	3442.79	3	10	West	West
3- 11W	235272.377	771889.46	171312.829	562048.84	1050.535	3446.63	3	11	West	East
	235085.363	771275.90	170737.259	560160.49	1050.535	3446.63	3	11	West	West
3- 12W	235185.732	771605.19	171308.288	562033.94	1051.706	3450.47	3	12	West	East
	234998.719	770991.63	170732.718	560145.59	1051.706	3450.47	3	12	West	West

Label	Northing		Easting		Elevation		Panel	Drift	Zone	Side
	meters	feet	meters	feet	meters	feet				
3- 13W	235099.088	771320.92	171303.747	562019.04	1052.877	3454.31	3	13	West	East
	234912.075	770707.37	170728.177	560130.69	1052.877	3454.31	3	13	West	West
3- 14W	235012.444	771036.66	171299.207	562004.15	1054.049	3458.16	3	14	West	East
	234825.43	770423.10	170723.637	560115.80	1054.049	3458.16	3	14	West	West
3- 15W	234925.799	770752.39	171294.666	561989.25	1055.22	3462.00	3	15	West	East
	234738.786	770138.83	170719.096	560100.90	1055.22	3462.00	3	15	West	West
3- 16W	234839.155	770468.13	171290.125	561974.35	1056.391	3465.84	3	16	West	East
	234652.142	769854.57	170714.555	560086.00	1056.391	3465.84	3	16	West	West
3- 17W	234752.51	770183.86	171285.584	561959.45	1057.563	3469.69	3	17	West	East
	234565.497	769570.30	170710.014	560071.10	1057.563	3469.69	3	17	West	West
3- 18W	234665.866	769899.60	171281.043	561944.56	1058.734	3473.53	3	18	West	East
	234478.853	769286.04	170705.473	560056.21	1058.734	3473.53	3	18	West	West
3- 19W	234579.222	769615.33	171276.503	561929.66	1059.905	3477.37	3	19	West	East
	234392.207	769001.77	170700.933	560041.31	1059.905	3477.37	3	19	West	West
3- 20W	234492.578	769331.07	171271.962	561914.76	1061.077	3481.22	3	20	West	East
	234305.564	768717.50	170696.392	560026.41	1061.077	3481.22	3	20	West	West
3- 21W	234405.934	769046.80	171267.421	561899.86	1062.248	3485.06	3	21	West	East
	234218.92	768433.24	170691.851	560011.51	1062.248	3485.06	3	21	West	West
3- 22W	234319.29	768762.54	171262.88	561884.97	1063.419	3488.90	3	22	West	East
	234132.276	768148.98	170687.31	559996.62	1063.419	3488.90	3	22	West	West
4- 1	236042.732	774416.86	171062.509	561227.58	1038.822	3408.20	4	1		East
	235910.955	773984.52	170656.939	559896.97	1038.822	3408.20	4	1		West
4- 2	235943.937	774092.73	171020.573	561090.00	1039.993	3412.04	4	2		East
	235759.426	773487.38	170452.704	559226.91	1039.993	3412.04	4	2		West
4- 3	235845.143	773768.61	170978.637	560952.41	1041.164	3415.89	4	3		East
	235659.733	773160.31	170408.004	559080.26	1041.164	3415.89	4	3		West
4- 4	235746.348	773444.48	170936.701	560814.83	1042.336	3419.73	4	4		East
	235560.938	772836.18	170366.068	558942.67	1042.336	3419.73	4	4		West
4- 5	235647.553	773120.35	170894.765	560677.24	1043.507	3423.57	4	5		East
	235462.144	772512.05	170324.132	558805.09	1043.507	3423.57	4	5		West
4- 6	235548.758	772796.22	170852.83	560539.66	1044.678	3427.41	4	6		East
	235363.349	772187.92	170282.196	558667.50	1044.678	3427.41	4	6		West
4- 7	235449.963	772472.09	170810.894	560402.07	1045.85	3431.26	4	7		East
	235264.554	771863.79	170240.26	558529.92	1045.85	3431.26	4	7		West
4- 8	235351.169	772147.96	170768.958	560264.49	1047.021	3435.10	4	8		East
	235165.759	771539.66	170198.324	558392.33	1047.021	3435.10	4	8		West
4- 9	235252.842	771825.37	170728.461	560131.63	1048.192	3438.94	4	9		East
	235061.884	771198.86	170140.754	558203.46	1048.192	3438.94	4	9		West
4- 10	235155.124	771504.77	170689.838	560004.91	1049.363	3442.79	4	10		East
	234973.145	770907.73	170129.767	558167.41	1049.363	3442.79	4	10		West

Label	Northing		Easting		Elevation		Panel	Drift	Zone	Side
	meters	feet	meters	feet	meters	feet				
4- 11	235068.48	771220.50	170685.297	559990.01	1050.535	3446.63	4	11		East
	234886.501	770623.46	170125.226	558152.51	1050.535	3446.63	4	11		West
4- 12	234981.835	770936.24	170680.756	559975.11	1051.706	3450.47	4	12		East
	234799.857	770339.20	170120.686	558137.62	1051.706	3450.47	4	12		West
4- 13	234895.191	770651.97	170676.215	559960.22	1052.877	3454.31	4	13		East
	234713.213	770054.93	170116.145	558122.72	1052.877	3454.31	4	13		West
4- 14	234808.547	770367.71	170671.674	559945.32	1054.049	3458.16	4	14		East
	234626.568	769770.67	170111.604	558107.82	1054.049	3458.16	4	14		West
4- 15	234721.902	770083.44	170667.133	559930.42	1055.22	3462.00	4	15		East
	234539.924	769486.40	170107.063	558092.92	1055.22	3462.00	4	15		West
4- 16	234635.258	769799.18	170662.593	559915.52	1056.391	3465.84	4	16		East
	234453.28	769202.14	170102.522	558078.02	1056.391	3465.84	4	16		West
4- 17	234548.614	769514.91	170658.052	559900.63	1057.563	3469.69	4	17		East
	234366.636	768917.87	170097.981	558063.13	1057.563	3469.69	4	17		West
4- 18	234461.969	769230.64	170653.511	559885.73	1058.734	3473.53	4	18		East
	234279.992	768633.61	170093.441	558048.23	1058.734	3473.53	4	18		West
4- 19	234375.325	768946.38	170648.97	559870.83	1059.905	3477.37	4	19		East
	234193.347	768349.34	170088.9	558033.33	1059.905	3477.37	4	19		West
4- 20	234288.681	768662.11	170644.429	559855.93	1061.077	3481.22	4	20		East
	234106.823	768065.47	170084.731	558019.65	1061.077	3481.22	4	20		West
4- 21	234202.036	768377.85	170639.888	559841.03	1062.248	3485.06	4	21		East
	234023.727	767792.84	170091.111	558040.59	1062.248	3485.06	4	21		West
4- 22	234116.274	768096.48	170638.061	559835.04	1063.419	3488.90	4	22		East
	233940.912	767521.14	170098.356	558064.36	1063.419	3488.90	4	22		West
4- 23	234036.36	767834.29	170654.237	559888.11	1064.59	3492.74	4	23		East
	233858.098	767249.44	170105.601	558088.13	1064.59	3492.74	4	23		West
4- 24	233949.716	767550.03	170649.696	559873.21	1065.762	3496.59	4	24		East
	233775.283	766977.74	170112.847	558111.90	1065.762	3496.59	4	24		West
4- 25	233863.071	767265.76	170645.156	559858.32	1066.933	3500.43	4	25		East
	233692.467	766706.04	170120.092	558135.67	1066.933	3500.43	4	25		West
4- 26	233776.427	766981.49	170640.615	559843.42	1068.105	3504.27	4	26		East
	233609.653	766434.34	170127.338	558159.44	1068.104	3504.27	4	26		West
4- 27	233689.782	766697.23	170636.074	559828.52	1069.276	3508.12	4	27		East
	233526.841	766162.64	170134.594	558183.25	1069.276	3508.12	4	27		West
4- 28	233605.914	766422.07	170640.076	559841.65	1070.447	3511.96	4	28		East
	233448.442	765905.43	170155.429	558251.60	1070.447	3511.96	4	28		West
4- 29	233526.916	766162.89	170659.069	559903.96	1071.618	3515.80	4	29		East
	233378.792	765676.92	170203.192	558408.31	1071.618	3515.80	4	29		West
4- 30	233442.259	765885.14	170660.645	559909.13	1072.79	3519.65	4	30		East
	233321.782	765489.88	170289.858	558692.64	1072.79	3519.65	4	30		West

Label	Northing		Easting		Elevation		Panel	Drift	Zone	Side
	meters	feet	meters	feet	meters	feet				
2- 1	233366.199	765635.60	171212.931	561721.09	1076.304	3531.17	2	1		East
	233138.688	764889.18	170512.724	559423.83	1076.304	3531.17	2	1		West
2- 2	233279.555	765351.34	171208.39	561706.19	1077.476	3535.02	2	2		East
	233043.824	764577.95	170482.884	559325.93	1077.476	3535.02	2	2		West
2- 3	233192.91	765067.07	171203.849	561691.29	1078.647	3538.86	2	3		East
	232957.408	764294.43	170479.049	559313.35	1078.647	3538.86	2	3		West
2- 4	233106.266	764782.81	171199.308	561676.40	1079.818	3542.70	2	4		East
	232871.754	764013.41	170477.554	559308.44	1079.818	3542.70	2	4		West
2- 5	233019.621	764498.54	171194.767	561661.50	1080.99	3546.55	2	5		East
	232786.099	763732.39	170476.058	559303.53	1080.99	3546.55	2	5		West
2- 6	232932.977	764214.28	171190.226	561646.60	1082.161	3550.39	2	6		East
	232700.444	763451.37	170474.563	559298.63	1082.161	3550.39	2	6		West
2- 7	232846.332	763930.01	171185.686	561631.70	1083.332	3554.23	2	7		East
	232614.789	763170.35	170473.068	559293.72	1083.332	3554.23	2	7		West
2- 8	232759.688	763645.74	171181.145	561616.81	1084.504	3558.08	2	8		East
	232529.134	762889.33	170471.573	559288.82	1084.504	3558.08	2	8		West
2- 9	232673.043	763361.48	171176.604	561601.91	1085.675	3561.92	2	9		East
	232443.479	762608.31	170470.078	559283.91	1085.675	3561.92	2	9		West
2- 10	232586.399	763077.21	171172.063	561587.01	1086.847	3565.76	2	10		East
	232357.824	762327.29	170468.583	559279.01	1086.847	3565.76	2	10		West
2- 11	232499.755	762792.95	171167.522	561572.11	1088.018	3569.61	2	11		East
	232273.136	762049.45	170470.061	559283.86	1088.018	3569.61	2	11		West
2- 12	232413.11	762508.68	171162.981	561557.21	1089.189	3573.45	2	12		East
	232188.446	761771.60	170471.539	559288.71	1089.189	3573.45	2	12		West
2- 13	232326.465	762224.41	171158.44	561542.32	1090.361	3577.29	2	13		East
	232103.758	761493.75	170473.018	559293.56	1090.361	3577.29	2	13		West
2- 14	232239.821	761940.15	171153.9	561527.42	1091.532	3581.13	2	14		East
	232019.069	761215.90	170474.496	559298.41	1091.532	3581.13	2	14		West
2- 15	232153.176	761655.88	171149.359	561512.52	1092.703	3584.98	2	15		East
	231934.38	760938.05	170475.974	559303.26	1092.703	3584.98	2	15		West
2- 16	232066.531	761371.61	171144.818	561497.62	1093.875	3588.82	2	16		East
	231849.692	760660.20	170477.452	559308.11	1093.875	3588.82	2	16		West
2- 17	231979.887	761087.35	171140.277	561482.73	1095.046	3592.66	2	17		East
	231765.002	760382.34	170478.931	559312.96	1095.046	3592.66	2	17		West
2- 18	231893.243	760803.08	171135.736	561467.83	1096.218	3596.51	2	18		East
	231681.102	760107.08	170482.833	559325.76	1096.218	3596.51	2	18		West
2- 19	231806.598	760518.81	171131.195	561452.93	1097.389	3600.35	2	19		East
	231597.515	759832.85	170487.704	559341.74	1097.389	3600.35	2	19		West
2- 20	231719.953	760234.55	171126.654	561438.03	1098.56	3604.19	2	20		East
	231513.079	759555.83	170489.959	559349.14	1098.56	3604.19	2	20		West

Label	Northing		Easting		Elevation		Panel	Drift	Zone	Side
	meters	feet	meters	feet	meters	feet				
2- 21	231633.309	759950.28	171122.114	561423.14	1099.732	3608.04	2	21		East
	231427.892	759276.34	170489.905	559348.96	1099.732	3608.04	2	21		West
2- 22	231546.664	759666.01	171117.573	561408.24	1100.903	3611.88	2	22		East
	231341.922	758994.29	170487.44	559340.88	1100.903	3611.88	2	22		West
2- 23	231460.02	759381.75	171113.032	561393.34	1102.074	3615.72	2	23		East
	231256.87	758715.25	170487.8	559342.06	1102.074	3615.72	2	23		West
2- 24	231373.375	759097.48	171108.491	561378.44	1103.246	3619.57	2	24		East
	231172.181	758437.40	170489.278	559346.91	1103.246	3619.57	2	24		West
2- 25	231286.731	758813.22	171103.95	561363.54	1104.417	3623.41	2	25		East
	231089.313	758165.52	170496.36	559370.14	1104.417	3623.41	2	25		West
2- 26	231188.179	758489.88	171062.762	561228.41	1105.589	3627.25	2	26		East
	231013.008	757915.18	170523.641	559459.65	1105.589	3627.25	2	26		West
2- 27	231088.605	758163.20	171018.429	561082.96	1106.76	3631.10	2	27		East
	230943.765	757688.00	170572.657	559620.46	1106.76	3631.10	2	27		West

ATTACHMENT IV
FLEXIBILITY CALCULATIONS

The required emplacement drift length for each WP type is determined by multiplying the total number of WPs, by type, with the length of the WP plus the WP spacing and rounding to one decimal place. The cumulative required emplacement drift length for each WP type is summed to get the total required emplacement drift length for any given WP spacing. Table IV- 1 provides a calculation for a WP spacing of 0.1 meters (0.3 feet).

Table IV- 1. Required Emplacement Length Sample Calculation

Type of WP (see Section 5.1.5)	WP Quantities (see Section 5.1.5)	WP Length (see Section 5.1.5)		Required Emplacement Drift Length	
		meters	inches	meters	feet
21 PWR AP	4,299	5.149	202.7	22,135.551	72,623.1
21 PWR CR	95	5.149	202.7	489.155	1,604.8
12 PWR AP Long	163	5.707	224.7	930.241	3,052.0
44 BWR AP	2,831	5.171	203.6	14,639.101	48,028.5
24 BWR AP	84	5.171	203.6	434.364	1,425.1
Total CSNF	*7,472*				
5 DHLW Short/1 DSNF Short	1147	3.627	142.8	4,160.169	
5 DHLW Long/1 DOE SNF Long	1,406	5.204	204.9	7,316.824	13,648.8
2 MCO/2 DHLW	149	5.204	204.9	775.396	24,005.3
5 DHLW Long/1 DOE SNF Short	31	5.204	204.9	161.324	2,543.9
HLW Long Only	679	5.204	204.9	3,533.516	529.3
Naval Short	144	5.367	211.3	772.848	11,592.9
Naval Long	156	6.002	236.3	936.312	2,535.6
Total DOE/HLW	*3,712*				
TOTAL	11,184			57,403.2	188,330.3

Table IV- 3. Cumulative Emplacement Drift Length

Drift	Available Drift Length		Cum. Available Drift Length	
	meters	feet	meters	feet
PANEL 1				
1	477.463	1,566.5	477.463	1,566.5
2	579.551	1,901.4	1,057.014	3,467.9
3	580.555	1,904.7	1,637.569	5,372.6
4	580.555	1,904.7	2,218.124	7,277.3
5	574.221	1,883.9	2,792.345	9,161.2
6	527.225	1,729.7	3,319.570	10,891.0
7	434.704	1,426.2	3,754.274	12,317.1
8	338.018	1,109.0	4,092.292	13,426.1
PANEL 3				
W1	600.000	1,968.5	4,692.292	15,394.6
W2	600.000	1,968.5	5,292.292	17,363.1
W3	600.000	1,968.5	5,892.292	19,331.6
W4	600.000	1,968.5	6,492.292	21,300.1
W5	600.000	1,968.5	7,092.292	23,268.6
W6	600.000	1,968.5	7,692.292	25,237.1

Drift	Available Drift Length		Cum. Available Drift Length	
	meters	feet	meters	feet
W7	600.000	1,968.5	8,292.292	27,205.6
W8	600.000	1,968.5	8,892.292	29,174.1
W9	603.339	1,979.5	9,495.631	31,153.6
W10	606.284	1,989.1	10,101.915	33,142.7
W11	605.190	1,985.5	10,707.105	35,128.2
W12	605.190	1,985.5	11,312.295	37,113.8
W13	605.190	1,985.5	11,917.485	39,099.3
W14	605.190	1,985.5	12,522.675	41,084.8
W15	605.190	1,985.5	13,127.865	43,070.3
W16	605.190	1,985.5	13,733.055	45,055.9
W17	605.190	1,985.5	14,338.245	47,041.4
W18	605.190	1,985.5	14,943.435	49,026.9
W19	605.190	1,985.5	15,548.625	51,012.4
W20	605.190	1,985.5	16,153.815	52,998.0
W21	605.190	1,985.5	16,759.005	54,983.5
W22	605.190	1,985.5	17,364.195	56,969.0
E1	467.366	1,533.3	17,831.561	58,502.4
E2	606.689	1,990.4	18,438.250	60,492.8
E3	703.886	2,309.3	19,142.136	62,802.2
E4	777.466	2,550.7	19,919.602	65,352.9
E5	770.456	2,527.7	20,690.058	67,880.6
E6	765.335	2,510.9	21,455.393	70,391.6
E7	747.727	2,453.2	22,203.120	72,844.7
E8	697.819	2,289.4	22,900.939	75,134.2
E9	647.912	2,125.7	23,548.851	77,259.9
E10	598.005	1,962.0	24,146.856	79,221.8
E11	548.097	1,798.2	24,694.953	81,020.0
E12	498.191	1,634.5	25,193.144	82,654.5
E13	462.981	1,519.0	25,656.125	84,173.5
E14	445.160	1,460.5	26,101.285	85,634.0
E15	421.851	1,384.0	26,523.136	87,018.0
E16	415.232	1,362.3	26,938.368	88,380.3
E17	400.290	1,313.3	27,338.658	89,693.6
E18	384.618	1,261.9	27,723.276	90,955.4
E19	368.946	1,210.5	28,092.222	92,165.9
PANEL 4				
1	426.441	1,399.1	28,518.663	93,565.0
2	597.093	1,959.0	29,115.756	95,523.9
3	600.000	1,968.5	29,715.756	97,492.4
4	600.000	1,968.5	30,315.756	99,460.9
5	600.000	1,968.5	30,915.756	101,429.4
6	600.000	1,968.5	31,515.756	103,397.9
7	600.000	1,968.5	32,115.756	105,366.4
8	600.000	1,968.5	32,715.756	107,334.9
9	617.952	2,027.4	33,333.708	109,362.3
10	588.893	1,932.1	33,922.601	111,294.4
11	588.893	1,932.1	34,511.494	113,226.5
12	588.893	1,932.1	35,100.387	115,158.5
13	588.893	1,932.1	35,689.280	117,090.6
14	588.893	1,932.1	36,278.173	119,022.6

Drift	Available Drift Length		Cum. Available Drift Length	
	meters	feet	meters	feet
15	588.893	1,932.1	36,867.066	120,954.7
16	588.893	1,932.1	37,455.959	122,886.8
17	588.893	1,932.1	38,044.852	124,818.8
18	588.893	1,932.1	38,633.745	126,750.9
19	588.893	1,932.1	39,222.638	128,682.9
20	588.501	1,930.8	39,811.139	130,613.7
21	577.019	1,893.1	40,388.158	132,506.8
22	567.480	1,861.8	40,955.638	134,368.6
23	576.870	1,892.6	41,532.508	136,261.2
24	564.477	1,852.0	42,096.985	138,113.2
25	552.084	1,811.3	42,649.069	139,924.5
26	539.692	1,770.6	43,188.761	141,695.1
27	527.288	1,729.9	43,716.049	143,425.1
28	509.588	1,671.9	44,225.637	145,096.9
29	479.337	1,572.6	44,704.974	146,669.6
30	389.869	1,279.1	45,094.843	147,948.7
PANEL 2				
1	736.241	2,415.5	45,831.084	150,364.1
2	762.842	2,502.8	46,593.926	152,866.9
3	762.100	2,500.3	47,356.026	155,367.2
4	758.897	2,489.8	48,114.923	157,857.0
5	755.696	2,479.3	48,870.619	160,336.4
6	752.493	2,468.8	49,623.112	162,805.2
7	749.290	2,458.3	50,372.402	165,263.5
8	746.088	2,447.8	51,118.490	167,711.2
9	742.885	2,437.3	51,861.375	170,148.5
10	739.683	2,426.8	52,601.058	172,575.3
11	733.354	2,406.0	53,334.412	174,981.3
12	727.026	2,385.3	54,061.438	177,366.6
13	720.696	2,364.5	54,782.134	179,731.1
14	714.368	2,343.7	55,496.502	182,074.8
15	708.039	2,323.0	56,204.541	184,397.7
16	701.710	2,302.2	56,906.251	186,699.9
17	695.381	2,281.4	57,601.632	188,981.4
18	686.503	2,252.3	58,288.135	191,233.7
19	676.607	2,219.8	58,964.742	193,453.5
20	669.461	2,196.4	59,634.203	195,649.9
21	664.744	2,180.9	60,298.947	197,830.8
22	662.561	2,173.8	60,961.508	200,004.5
23	657.408	2,156.8	61,618.916	202,161.4
24	651.079	2,136.1	62,269.995	204,297.5
25	638.858	2,096.0	62,908.853	206,393.5
26	566.866	1,859.8	63,475.719	208,253.3
27	468.713	1,537.8	63,944.432	209,791.0

ATTACHMENT V
ELECTRONIC VULCAN FILES

The attached CD contains the electronic file created by VULCAN V4.0NT (BSC 2002f) for the underground layout as developed in this analysis.

Filename	Description	Filesize	Date & Time
Subsurfaceladesign_m.dxf	Metric Layout	1,100 KB	05/19/03 7:04 am
Subsurfaceladesign_i.dxf	Imperial Layout	1,122 KB	05/19/03 7:04 am
TptpllPanel1.00t	Geological Triangulation	3 KB	05/16/03 11:28 am
TptpllPanel2.00t	Geological Triangulation	5 KB	05/01/03 6:47 am
TptpllPanel2cont.00t	Geological Triangulation	4 KB	05/01/03 6:47 am
TptpllPanel3e.00t	Geological Triangulation	4 KB	05/150/3 9:29 am
TptpllPanel3w.00t	Geological Triangulation	3 KB	05/01/03 6:47 am
TptpllPanel4.00t	Geological Triangulation	7 KB	05/01/03 6:47 am
TptpllPanel4north.00t	Geological Triangulation	4 KB	05/01/03 6:47 am
TptpllPanel4south.00t	Geological Triangulation	6 KB	05/01/03 6:47 am
TptplnPanel2.00t	Geological Triangulation	2 KB	05/01/03 6:47 am
TptplnPanel2cont.00t	Geological Triangulation	4 KB	05/01/03 6:47 am
TptplnPanel4.00t	Geological Triangulation	7 KB	05/01/03 6:47 am
TptpmnPanel1.00t	Geological Triangulation	3 KB	05/01/03 6:47 am
TptpmnPanel2.00t	Geological Triangulation	4 KB	05/01/03 6:47 am
TptpmnPanel2cont.00t	Geological Triangulation	2 KB	05/01/03 6:47 am
TptpmnPanel3e.00t	Geological Triangulation	8 KB	05/01/03 6:47 am
TptpmnPanel3w.00t	Geological Triangulation	3 KB	05/01/03 6:47 am
TptpulPanel3eaest.00t	Geological Triangulation	4 KB	05/16/03 1:25 pm
PtnThickness.00t	Geological Triangulation	2,103 KB	05/21/03 7:04 am
PtnThickness3.00t	Geological Triangulation	2,284 KB	05/21/03 8:06 am
Faulttrace	Traces of Faults	21 KB	05/21/03 1:53 pm