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Design Analysis Cover Sheet

Complete only applicable items.

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11. REMARKS

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1. PURPOSE

The objective of this document is to present a comparison between the Viability Assessment Design Layout and a 25 MTU/acre conceptual repository design. The scope of this analysis is comparing the linear dimensions and the quantities of the major design elements, for example, emplacement drifts, perimeter mains, exhaust mains, performance confirmation drifts, connecting ramps and vertical development.

2. QUALITY ASSURANCE

This document has been evaluated (Reference 5.1) in accordance with QAP-2-0, *Conduct of Activities* and has been determined to be subject to the requirements of the *Quality Assurance Requirements and Description* (QARD) (Reference 5.2). The classification of items in accordance with QAP-2-3, *Classification of Permanent Items*, evaluation entitled *Classification of the Preliminary MGDS Repository Design* (TBV) has identified emplacement drifts as important to waste isolation (QA-2) (Reference 5.3, Attachment V, p.3). The input data used in this analysis is preliminary and unqualified therefore the outputs are also unqualified. Due to the preliminary nature of this analysis, all data must be treated as unqualified/unconfirmed and the formal TBV and TBD tracking system as described in NLP-3-15, *To Be Verified (TBV) and To Be Determined (TBD) Monitoring System* does not apply. The conclusions from this design analysis cannot be used as input into documents supporting procurement, fabrication or construction. This document was prepared in accordance with QAP-3-9, *Design Analysis* and is subject to QA controls.

3. METHOD

3.1 AREAL MASS LOADING FORMULA

The Areal Mass Loading (AML) formula (Reference 5.4, p. 59) is used to calculate the emplacement drift spacing. The formula is as follows:

$$\text{AML}\ \frac{MTU}{acre} = \frac{\text{Assembly Uranium Weight } (MTU/Assembly) * \text{Number of Assemblies}}{\text{WP spacing (m)} * \text{Drift Spacing (m)} * .00024711\ (Acres/m^2)}$$

3.2 CONCEPTUAL REPOSITORY DESIGN

A conceptual repository design was created to provide the plan drawing from which a comparison of the major design elements could be made with the Viability Assessment (VA) Reference Design (Reference 5.5, p.33). The AML formula was used to calculate the emplacement drift spacing that would result in a 25 MTU/acre thermal load (Section 4.3.1). The proposed design is used to illustrate the repository siting within the suitable host formation. The conceptual repository design is used to measure the lineal distances for the horizontal development. In addition, the conceptual repository design is used to quantify the major elements of the design such as the number of emplacement drifts and the total excavation length of these drifts.

4. DESIGN INPUTS

4.1 DESIGN PARAMETERS

4.1.1 Fuel Assembly (TBV)

Twelve potential commercial SNF waste streams have been analyzed and the recommended, repository design, reference fuel assembly has an average, uranium weight for a fuel assembly of 0.432 MTU/assembly (Reference 5.4, p. 67, 68). This is used in Section 7.1 and 7.2.

4.1.2 VA Reference Design (TBV)

The VA Reference Design is based on a AML of 85 MTU/acre with 28 meter spacing for the emplacement drifts (Reference 5.5, p. 107). This is used in Section 7.1 , 7.3.3 and 8.1.

4.1.3 Perimeter Main Length (TBV)

The VA Reference Design has 9959 meters of perimeter main drift remaining to be excavated. This is the sum of the North Main (1137 meters), West Main (3486 meters), East Main North Extension (1576 meters), North Ramp Extension (1491 meters) and the South Ramp Extension (2269 meters) (Reference 5.5, p. 62). This is used in Section 8.1.

4.1.4 Exhaust Main Length (TBV)

The VA Reference Design has 5048 meters of Exhaust Main to excavate (Reference 5.5, p. 62). This is used in Section 8.1.

4.1.5 Performance Confirmation Drifts (TBV)

The VA Reference Design has 10436 meters of Performance Confirmation drift excavation (Reference 5.5, Attachment V, p. 1 of 4). This is used in Section 8.1.

4.1.6 Repository Shafts (TBV)

The VA Reference Design has two shafts used for subsurface ventilation purposes (Reference 5.5, p. 78). This is used in Section 8.1.

4.2 CRITERIA

4.2.1 Fault Standoff Distance (TBV)

Type I fault standoff distance is 15 meters from the fault to the nearest waste package. Those faults not considered Type I faults, or splays of Type I faults, will have a 5 meter standoff from the fault to the nearest waste package (Reference 5.10, p. 8). This is used in Attachment II and Attachment III.

4.2.2 Ventilation Strategy (TBV)

Ventilation shafts are required to ventilate three separate emplacement blocks during development and construction. In addition, the shafts are required to support and isolate simultaneous repository development/construction from waste emplacement operations (Reference 5.11, p. 8). This is used to develop the conceptual repository design and in Section 7.3.4.

4.3 ASSUMPTIONS

4.3.1 Thermal Load Limit (TBV)

The maximum thermal load that the conceptual repository can exert upon the host, geologic formation is 25 MTU/acre (Reference 5.6). This is used in Section 7.2 and Section 8.1.

4.3.2 Waste Inventory (TBV)

The conceptual repository is designed to accommodate 63,000 MTU CSNF and 7000 MTU HLW (Reference 5.6). This is used in Section 7.3.3.

4.3.3 Waste Package (TBV)

The representative waste package selected for this document is the 21 PWR waste package (Reference 5.9, Vol. 3, p. 2-12,2-13). This is used in Section 7.1 and 7.2.

4.3.4 Conceptual Repository Geologic Location (TBV)

The conceptual repository design is composed of three distinct zones. They are referred to as the Lower Block, Upper Block and Area 5. The Lower Block and Area 5 (composed of the Boomerang Point Block and part of the Jet Ridge Fault Block) are located in the potential expansion area of the repository host horizon in the TSw2 geologic unit (Reference 5.7 , p. 8). The Upper Block is situated in the existing repository host horizon (Reference 5.8 , p. 77). This assumption is used in Section 7.3.3 and 8.1 and to develop the conceptual repository design illustrated in Attachment III.

4.3.5 Repository Design Geometry (TBV)

The primary excavation method will be mechanical, utilizing TBM and roadheader equipment for horizontal development and raiseborer for vertical development. (Reference 5.5, p. 19) This equipment dictates that the curve radius for the drifts will be a minimum of 305 meters for the mains and roadheader excavations will have a minimum radius of 20 meters. (Reference 5.5, p. 25) This assumption is used in the design of the conceptual repository illustrated in Attachment III.

4.3.6 Type I faults (TBV)

Type I faults intersect the Upper Block (Reference 5.8, p. 10,53). In the potential expansion area of the repository host horizon, additional Type I faults are encountered (Reference 5.7, p. 3,8). They are incorporated into the conceptual repository. This is used to develop the design for the conceptual repository illustrated in Attachment III and used in Attachment II and Section 7.3.3.

4.3.7 VA Design, Useable Emplacement Drift Length (TBV)

The VA Reference Design has a useable emplacement drift length of 108,003 meters and a nominal 116,957 meters of excavated length to produce the 105 emplacement drifts. Five of the emplacement drifts will remain unoccupied. (Reference 5.5, p. 47). This assumption is used in Section 7.3.3 and Section 8.1 and in Attachment II.

4.3.8 Turnout Distance (TBV)

An average turnout distance of 35 meters from the perimeter mains into the emplacement drifts is applied. This is based on using a weighted average of the VA Reference Design values (Reference 5.5, p. 87). This assumption is used in Attachment II.

4.3.9 Thermal and Radiological Standoff (TBV)

An average thermal/radiological standoff distance of 15 meters is applied for the conceptual repository design based on the VA Reference Design parameters Thermal and Radiological Standoff Distances (Reference 5.5, p. 23). This assumption is used in Attachment II.

4.3.10 Ventilation Raise Standoff (TBV)

Ventilation raise standoff is 2 meters from the centerline of the ventilation raise to the nearest waste package is applied for the conceptual repository design based on the VA Reference Design (Reference 5.5, p. 25). This assumption is used in Attachment II.

4.3.11 Ventilation Raises (TBV)

There is one ventilation raise, 10 meters in length, from the Exhaust Main into each emplacement drift in the conceptual repository design. This is based on the VA Reference Design (Reference 5.5, p. 26). This assumption is used in Section 7.3.1 and Attachment I.

4.3.12 Unoccupied Emplacement Drifts (TBV)

The conceptual repository design has twelve drifts that will support the repository ventilation, monitoring and contingencies. There is an increase from the VA Reference Design of five drifts (Reference 5.5, p. 47) because of the larger emplacement area. This assumption is used in Section 7.3.3 and Attachment II.

4.3.13 Measurements

All the dimensions obtained from the conceptual design repository layout, illustrated in Attachment III, are measured to ±five meters. The basis for this assumption is the layout scale is so large that precise dimensions cannot be obtained. This is used Section 7.3.1 and Attachment I and II.

4.4 CODES AND STANDARDS

"NOT USED"

5. REFERENCES

5.1 CRWMS M&O 1998. *Activity Evaluation, Support Development of Repository Design Alternatives – Work Package 12012382M2.* Las Vegas, Nevada: CRWMS M&O. ACC: MOL. 19981224.0055

5.2 DOE 1998. *Quality Assurance Requirements and Description.* DOE/RW-0333P, REV 08. Washington D.C.: U.S. Department of Energy. MOL.19980601.0022

5.3 CRWMS M&O 1998. *Classification of the Preliminary MGDS Repository Design.* B00000000-01717-0200-00134 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981103.0546

5.4 CRWMS M&O 1997. *Preliminary Design Basis for WP Thermal Analysis.* BBAA00000-01717-0200-00019 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980203.0529

5.5 CRWMS M&O 1997. *Repository Subsurface Layout Configuration Analysis.* BCA000000-01717-0200-00008 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971201.0879

5.6 CRWMS M&O 1998. Design Input Request. SEI-SSR-99011.R. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990401.0144

5.7 CRWMS M&O 1999. *Identification of Potential Repository Expansion Areas.* BCA000000-01717-0210-00002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990126.0231

5.8 CRWMS M&O 1997. *Determination of Available Volume for Repository Siting.* BCA000000-01717-0200-00007 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971009.0699

5.9 DOE 1998. *Viability Assessment of a Repository at Yucca Mountain. Volume 3: Total System Performance Assessment.* Las Vegas, Nevada: U.S. Department of Energy. ACC: 19981007.0030

5.10 CRWMS M&O 1998. *Subsurface Facility System Description Document.* BCA000000-01717-1705-00014 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981214.0020

5.11 CRWMS M&O 1998. *Subsurface Ventilation System Description Document.* BCA000000-01717-1705-00016 REV 00. ICN 1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980511.0220, MOL.19981117.0420

6. USE OF COMPUTER SOFTWARE

"NOT USED"

7. DESIGN ANALYSIS

7.1 VA REFERENCE DESIGN AVERAGE WASTE PACKAGE SPACING

Apply the AML formula (Section 3.1). Substitute the known values into the equation and solve for the average waste package spacing in the VA Reference Design.

Let: a = AML b = Assembly Uranium Weight
c = Number of Assemblies d = WP spacing
e = Drift Spacing Conversion factor 0.0002471 acres/m^2

AML equation expressed in terms of the above variables:

$$a = \frac{b * c}{d * e * 0.0002471}$$

Re-arrange equation to solve for the average waste package spacing:

$$d = \frac{b * c}{a * e * 0.0002471}$$

Substitute known values:

Thermal Load (AML)	Assemblies	MTU/Assembly	Emp Dr Spacing
a	C	b	e
85 MTU/acre	21	.432 MTU/assembly	28 m
Section 4.1.2	Section 4.3.3	Section 4.1.1	Section 4.1.2

Solving for the Waste Package spacing, produces 15.43 meters.

7.2 EMPLACEMENT DRIFT SPACING FOR THE CONCEPTUAL DESIGN REPOSITORY

Re-arrange AML equation in Section 7.1. Substitute the known values into the equation and solve for the emplacement drift spacing:

$$e = \frac{b * c}{d * a * 0.0002471}$$

Substitute known values:

Thermal Load (AML)	MTU/Assembly	Assemblies	WPspacing
a	b	C	d
25 MTU/acre	.432 MTU/assembly	21	15.43 m
Section 4.3.1	Section 4.1.1	Section 4.3.3	Section 7.1

The emplacement drift spacing is 95.2 meters.

7.3 CONCEPTUAL REPOSITORY DESIGN

The conceptual repository design is illustrated in Figure 1 and Attachment III. The conceptual repository will have longer lengths for the major elements since the drift spacing is wider which results in longer perimeter mains. It extends beyond the existing VA Reference Design boundaries, therefore connecting ramps are introduced into the design. There are more emplacement drifts because of an increase in the standoff distances and the number of unoccupied drifts required to support the expanded conceptual repository. The following sections discuss the impact of the conceptual repository design on the major design elements.

7.3.1 Measured Lineal Distances

The lineal distances are measured with a scale, to a ±five meter precision (Section 4.3.13), from the conceptual repository design presented in Attachment III. The lengths for the ramps, perimeter mains, exhaust mains and P.C. drifts are compiled in Attachment I. The measurements for the emplacement drifts, their turnouts and standoff distances are compiled in Attachment II. Ventilation raises are considered 10 meters in length (Section 4.3.11) and their total length is found in Attachment I. Section 8.1, Table 1 summarizes these elements.

7.3.2 Quantities

Quantities are a count of the major elements. This includes the emplacement drifts, ventilation raises and shafts. Attachment III in conjunction with Figure 1 are used to generate these numbers. The number of shafts and ventilation raises can be found in Attachment I. The number of emplacement drifts can be found in Attachment II. Section 8.1, Table 1 summarizes the number of each of the major elements.

7.3.3 Length of Emplacement Drift to Support Waste Inventory

In the VA Reference Design emplacement drifts are at 28 meter centers (Section 4.1.2). The total useable emplacement drift length is 108,003 meters (Section 4.3.7). In order to achieve this useable emplacement drift length it was necessary to design 116,957 meters of emplacement drift excavation (Section 4.3.7). The conceptual repository will also have a corresponding relationship of excavated length of emplacement drift to the useable length of emplacement drift. This is to be consistent with the VA Reference Design derivation since both are required to accept 63,000 MTU of CSNF (Section 4.3.2). The conceptual repository has a larger emplacement drift spacing (in order to reduce the thermal load) which equates to a larger occupied area of the suitable host formation. The Upper Block (Section 4.3.4) does not have sufficient, suitable host formation to accommodate the expanded conceptual repository design. Therefore, the conceptual design goes outside the boundary of the VA Reference Design and enters into the potential expansion area of the Lower Block and Area 5 zones (Section 4.3.4). In doing so, additional fault structure is encountered (Section 4.3.6). Also, (Refer to Attachment I) due to the wider emplacement drift spacing, more emplacement drifts are designed for excavation: 144. There is a corresponding increase in the total standoff distance (10,080 meters for turnouts, 4,320 meters for thermal/radiological, 576 meters for ventilation raises and 2,375 meters for faults). Therefore, the total length of emplacement drift excavation necessary to provide the corresponding length of useable emplacement drift increases. In addition, the conceptual design incorporates 12 drifts (Reference 4.3.12) for ventilation, monitoring and standby purposes due to the additional two emplacement areas. These provisions increase the

final design length for emplacement drifts to 141,965 meters to give a useable emplacement length of 113,392 meters (Refer to Attachment II). Section 8.1, Table 1 summarizes these values.

7.3.4 Additional Development

In order to access the extended emplacement area more perimeter mains and ramps are required to be excavated (Refer to Attachment I). This amounts to 38,330 meters of perimeter main drift and 14,205 meters of interconnecting ramp. More Performance Conformation drifts are also added to the conceptual design to increase the monitoring coverage necessary in the expanded areas. This amounts to 10,415 meters of drift. For ventilation purposes, the two additional emplacement areas each has its own exhaust main drift. The total length of exhaust main drift is 20,565 meters. All emplacement drifts are connected to an exhaust main with a single ventilation raise (Section 4.3.11) which results in 144 ventilation raises. This increases the total length of ventilation raise to 1440 meters. In conjunction with this, five shafts are included in the conceptual design to provide ventilation during pre-emplacement construction and maintain isolated ventilation systems during simultaneous emplacement and construction (Section 4.2.2)(Refer to Attachment I). Section 8.1, Table 1 summarizes these values.

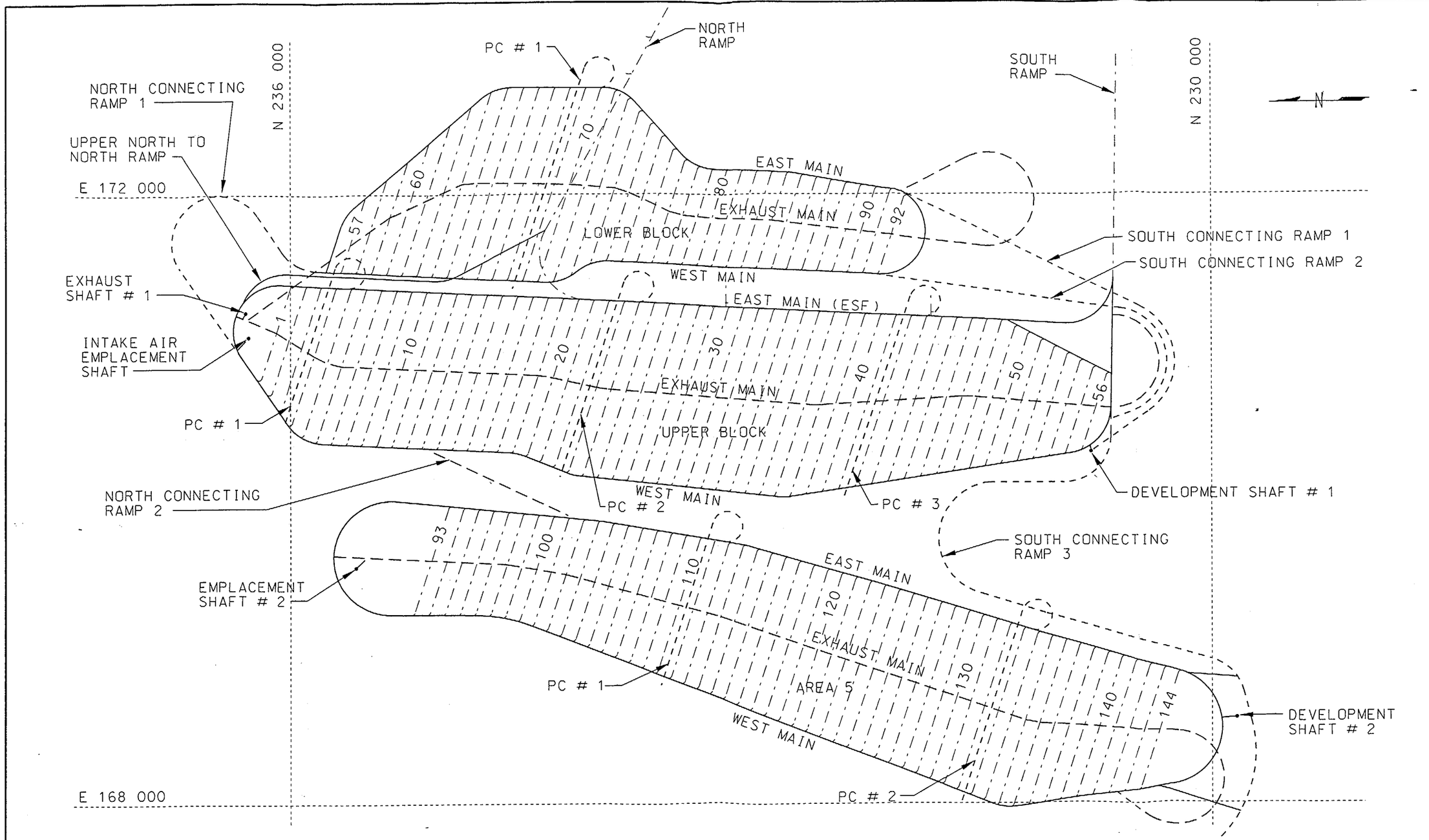

FIGURE 1 ALTERNATIVE # 2
– 25 MTU/ACRE
DRIFT SPACING 95.2 m

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8. CONCLUSIONS

8.1 COMPARISON TABLE

Table 1 presents a quantitative comparison between the VA Reference Design repository and the conceptual repository design.

Table 1 Design Comparison of a 25 MTU/acre Low Thermal Load Repository with the 85 MTU/ acre Thermal Load VA Reference Design Repository

Thermal Load Condition	**25 MTU/acre** (Section 4.3.1)	**85 MTU/acre** (Section 4.1.2)
Design	**Conceptual**	**VA**
Fuel Assembly & Spacing	**21 PWR/95.2 m** (Section 7.2)	**21 PWR/28m** (Section 7.1)
Block Names	Lower (Section 4.3.4)	N/A
	Upper (Section 4.3.4)	Upper (Section 4.3.4)
	Area 5 (Section 4.3.4)	N/A
EMPLACEMENT DRIFT		
Number	144 (Section 7.3.3)	105 (Section 4.3.7)
Emplacement Length	113,392 (Section 7.3.3)	108,003 (Section 4.3.7)
Nominal Length	131,885 (Attachment II)	116,957 (Section 4.3.7)
Perimeter Main Drift	38,330 (Section 7.3.4)	9,959 (Section 4.1.3)
Exhaust Main	20,565 (Section 7.3.4)	5,048 (Section 4.1.4)
Vent Raise Number	144 (Section 7.3.4)	105 (Section 4.3.7, 4.3.11)
Vent Raise Length	1,440 (Section 7.3.4)	1,050 (Section 4.3.7, 4.3.11)
PC Drifts	10,415 (Section 7.3.4)	10436 (Section 4.1.5)
Connecting **Ramps**	14,205 (Section 7.3.4)	0
Shaft Number	5 (Section 7.3.4)	2 (Section 4.1.6)

9. ATTACHMENTS

Attachment I Lateral Development Excluding Emplacement Drifts ,Shaft and Ventilation Raise
Attachment II Emplacement Drift Lineal Dimensions
Attachment III Figure Alternative #2 – 25 MTU/acre Drift Spacing 95.2

Lateral Development Excluding Emplacement Drifts Lengths
Refer to Attachment III and Figure 1

All dimensions are expressed in Meters

All dimensions ± 5 meters (Section 4.3.13)

Upper Block Perimeter Main	Length		Cumulative	Heading Type: Main
Sth Rmp Acc ESF to Corner 1(**Start Upper**)	860		860	
Curve 1		420	1280	
West Main	1850		3130	
Curve 2		80	3210	
West Main	1310		4520	
Curve 3		85	4605	
West Main	295		4900	
Curve 4		105	5005	
West Main	1210		6215	
Curve 5		280	6495	
West Main/North Connecting Ramp to Lower Block	530		7025	
Curve 6 North (West Main to East Main)		680	7705	
East Main	5100		12805	
Curve 7		490	13295	**Main** 13295

Upper Block Exhaust Main				Heading Type: Exhaust
Start Upper Exhaust Main		965	965	
	895		1860	
		95	1955	
	905		2860	
		80	2940	
	1320		4260	
		85	4345	
	295		4640	
		105	4745	
	1255		6000	
		190	6190	
	580		6770	**Exhaust** 6770

Upper Block PC Drift				Heading Type: PC
#1		470	470	
	1110		1580	
#2		470	2050	
	1300		3350	
#3		470	3820	
	1380		5200	**PC** 5200

Upper Block Total *25265*

Lower Block Perimeter Main				Heading Type: Main
West Main to East Main (**Start Lower**)	295		295	
Curve 1		170	465	
East Main	1090		1555	
Curve 2		215	1770	
East Main	575		2345	
Curve 3		255	2600	
East Main	440		3040	
Curve 4		240	3280	
East Main	1200		4480	
Curve 5 South (East Main to West Main)		830	5310	
West Main	1715		7025	
Curve 6		225	7250	
Curve 7		225	7475	
West Main	1420		8895	**Main** 8895

Lower Block Exhaust Main				Heading Type: Exhaust
Start Lower Exhaust Main	475		475	
		1145	1620	
	1860		3480	
		95	3575	
		95	3670	
	290		3960	
		95	4055	
	890		4945	
		105	5050	
	1675		6725	**Exhaust** 6725

Lower Block PC Drift				Heading Type: PC
#1	1465	470	1935	**PC** 1935

Lower Block Total *17555*

Area 5 Perimeter Main			
Curve 1 South (East Mn to West Mn) Start Area 5		1040	1040
West Main	1030		2070
Curve 2		155	2225
West Main	3225		5450
Curve 3		365	5815
West Main	550		6365
Curve 4 North (West Main to East Main)		1215	7580
East Main	2280		9860
Curve 5		35	9895
East Main	2920		12815

Main: 12815

Area 5 Exhaust Main			
Start Area 5 Exhaust Main	265		265
		1130	1395
	920		2315
		95	2410
	2000		4410
		95	4505
	1050		5555
		385	5940
	1130		7070

Exhaust: 7070

Area 5 PC Drift			
#1		470	470
	1080		1550
#2		470	2020
	1260		3280

PC: 3280

Area 5 Total: *23165*

Connecting Ramps Between Blocks			
North Connecting Ramp 1 (Upper to Lower)	705		705
		960	1665
	280		1945
		330	2275

Ramps: 2275

South Connecting Ramp 1 (Upper to Lower)			
	455		455
		840	1295
	1730		3025

Ramps: 3025

South Connecting Ramp 2 (Lower to Primary)			
	1635		1635
		945	2580
	145		2725

Ramps: 2725

South Connecting Ramp 3 (Upper to Area 5)			
	195		195
		470	665
	495		1160
		1040	2200
	1560		3760
		1350	5110

Ramps: 5110

North Connecting Ramp 2 (Area 5 to Upper)			1070

Ramps: 1070

Ramps Total: *14205*

Upper North to North Ramp			
		380	380
	955		1335
		160	1495
	640		2135

Main: 2135

Ramps: 2135

Shaft Accesses			300
South Connecting Ramp to Area 5	330		
	560		
	890		

Main: 300

Ramps: *300*

Main: 890

Ramps: *890*

Conceptual Repository Totals	Main	Exhaust	PC	Ramps	TOTAL
	38330	20565	10415	14205	83515

Shafts (from Attachment II)

Dev Shaft #1 Upper South	1
Intake Air Empl Shaft *Upper North*	1
Exhaust Shaft #1 *Upper North*	1
Dev Shaft #2 *Area 5 South*	1
Emplacement Shaft #2 *Area 5 North*	1
	5 Total

	Number	Length	Total
Section	*4.3.11*	*4.3.11*	
Ventilation Raises	144	10	1440

Emplacement Drift Lineal Dimensions (from Attachment III)

All dimensions are expressed in Meters ***All dimensions ±5 meters (Section 4.3.13)***

	Excavation	*deduct*		Nominal	Standoff (deduct)			Emplacement	
EmpDr	Length	WestTurn	EastTurn	Length	Rad/Thrml	VentRse	Fault	Length	
Section		***4.3.8***	***4.3.8***		***4.3.9***	***4.3.10***	***4.2.1***		
1	680	35	35	610	30	4		576	
2	780	35	35	710	30	4		676	
3	880	35	35	810	30	4		776	
4	970	35	35	900	30	4	10	856	
5	1030	35	35	960	30	4	10	916	
6	1060	35	35	990	30	4	10	946	
7	1065	35	35	995	30	4	10	951	
8	1065	35	35	995	30	4	20	941	
9	1065	35	35	995	30	4	10	951	
10	1065	35	35	995	30	4	10	951	
11	1065	35	35	995	30	4	10	951	
12	1065	35	35	995	30	4		961	
13	1065	35	35	995	30	4		961	
14	1065	35	35	995	30	4		961	*
15	1065	35	35	995	30	4		961	
16	1065	35	35	995	30	4		961	
17	1065	35	35	995	30	4		961	
18	1065	35	35	995	30	4		961	*
19	1065	35	35	995	30	4		961	
20	1090	35	35	1020	30	4		986	
21	1125	35	35	1055	30	4		1021	
22	1160	35	35	1090	30	4		1056	
23	1190	35	35	1120	30	4		1086	
24	1205	35	35	1135	30	4		1101	
25	1205	35	35	1135	30	4	10	1091	
26	1210	35	35	1140	30	4	10	1096	
27	1220	35	35	1150	30	4	10	1106	
28	1225	35	35	1155	30	4	10	1111	
29	1230	35	35	1160	30	4		1126	*
30	1235	35	35	1165	30	4		1131	
31	1240	35	35	1170	30	4		1136	
32	1245	35	35	1175	30	4		1141	
33	1250	35	35	1180	30	4	30	1116	*
34	1260	35	35	1190	30	4	30	1126	
35	1260	35	35	1190	30	4	30	1126	
36	1270	35	35	1200	30	4	30	1136	
37	1275	35	35	1205	30	4		1171	
38	1270	35	35	1200	30	4		1166	
39	1250	35	35	1180	30	4		1146	
40	1225	35	35	1155	30	4		1121	
41	1200	35	35	1130	30	4		1096	
42	1180	35	35	1110	30	4		1076	
43	1155	35	35	1085	30	4		1051	*
44	1135	35	35	1065	30	4		1031	
45	1115	35	35	1045	30	4	30	981	
46	1090	35	35	1020	30	4	30	956	
47	1070	35	35	1000	30	4	30	936	
48	1050	35	35	980	30	4	30	916	
49	1000	35	35	930	30	4	30	866	
50	930	35	35	860	30	4	30	796	
51	865	35	35	795	30	4	30	731	
52	805	35	35	735	30	4	30	671	
53	740	35	35	670	30	4	30	606	
54	680	35	35	610	30	4	30	546	
55	615	35	35	545	30	4	30	481	
56	540	35	35	470	30	4	30	406	
57	510	35	35	440	30	4		406	
58	640	35	35	570	30	4		536	
59	770	35	35	700	30	4		666	
60	900	35	35	830	30	4		796	
61	1030	35	35	960	30	4		926	
62	1160	35	35	1090	30	4		1056	
63	1265	35	35	1195	30	4	5	1156	
64	1300	35	35	1230	30	4	10	1186	*
65	1305	35	35	1235	30	4	10	1191	
66	1310	35	35	1240	30	4	10	1196	
67	1315	35	35	1245	30	4	20	1191	
68	1320	35	35	1250	30	4	30	1186	
69	1325	35	35	1255	30	4	30	1191	
70	1330	35	35	1260	30	4	30	1196	
71	1310	35	35	1240	30	4	30	1176	

Nomenclature:

Excavation Length
Emplacement Drift length
including turnouts
East Main to West Main
inside rib measurement

Nominal Length
Emplacement Drift length
excluding turnouts

Emplacement Length
Nominal length
less Standoff

SUMMARY

Number of Empl Drifts	144
Excavation Length	141965
Turnout Length	10080
Nominal Length	131885
Standoff	
Rad/Thrml	4320
VentRse	576
Fault	2375
Emplacement Length	124614
Unoccupied Empl Dr	12
Unoccupied Length	11222
Available for Empl	113392

Average Turnout Distance Calculation ***(Section 4.3.8)***	
Use 105 Emplacement Drifts ***(Section 4.3.7)***	
East Main	
105 (17.6+16) = 3528	
West Main	
1 Thru 29	
29 (17.6+16) = 974.4	
30 Thru 43	
14 (22.4+16) = 537.7	
44 Thru 91	
48 (18.7+16) = 1665.6	
92 Thru 105	
14 (13.4+16) = 411.6	
TOTAL	7117.3
Turnouts	210
AVERAGE	33.9
Roundoff	**35**
(Section 4.3.13)	

72	1220	35	35	1150	30	4	20	1096	
73	1060	35	35	990	30	4	20	936	
74	960	35	35	890	30	4	20	836	*
75	880	35	35	810	30	4	20	756	
76	795	35	35	725	30	4		691	
77	720	35	35	650	30	4		616	
78	675	35	35	605	30	4		571	
79	660	35	35	590	30	4		556	
80	660	35	35	590	30	4		556	
81	660	35	35	590	30	4		556	
82	660	35	35	590	30	4		556	
83	660	35	35	590	30	4		556	
84	660	35	35	590	30	4		556	
85	650	35	35	580	30	4		546	*
86	640	35	35	570	30	4		536	
87	625	35	35	555	30	4		521	
88	615	35	35	545	30	4		511	
89	600	35	35	530	30	4		496	
90	590	35	35	520	30	4		486	
91	580	35	35	510	30	4		476	
92	560	35	35	490	30	4	10	446	
93	750	35	35	680	30	4		646	
94	740	35	35	670	30	4		636	
95	730	35	35	660	30	4		626	
96	720	35	35	650	30	4		616	
97	715	35	35	645	30	4		611	
98	710	35	35	640	30	4		606	
99	710	35	35	640	30	4		606	
100	730	35	35	660	30	4		626	*
101	750	35	35	680	30	4		646	
102	775	35	35	705	30	4		671	
103	800	35	35	730	30	4		696	
104	820	35	35	750	30	4		716	
105	840	35	35	770	30	4		736	
106	860	35	35	790	30	4		756	
107	880	35	35	810	30	4		776	
108	900	35	35	830	30	4		796	
109	920	35	35	850	30	4		816	
110	940	35	35	870	30	4		836	
111	960	35	35	890	30	4		856	
112	975	35	35	905	30	4		871	
113	995	35	35	925	30	4		891	
114	1005	35	35	935	30	4	30	871	
115	1015	35	35	945	30	4	30	881	*
116	1025	35	35	955	30	4	30	891	
117	1035	35	35	965	30	4	30	901	
118	1040	35	35	970	30	4	30	906	
119	1050	35	35	980	30	4	30	916	
120	1060	35	35	990	30	4	30	926	
121	1070	35	35	1000	30	4	30	936	
122	1075	35	35	1005	30	4	30	941	
123	1080	35	35	1010	30	4	30	946	
124	1090	35	35	1020	30	4	60	926	
125	1095	35	35	1025	30	4	60	931	
126	1105	35	35	1035	30	4	60	941	
127	1110	35	35	1040	30	4	60	946	
128	1115	35	35	1045	30	4	60	951	
129	1120	35	35	1050	30	4	60	956	
130	1130	35	35	1060	30	4	90	936	*
131	1135	35	35	1065	30	4	90	941	
132	1145	35	35	1075	30	4	60	981	
133	1150	35	35	1080	30	4	60	986	
134	1155	35	35	1085	30	4	60	991	
135	1160	35	35	1090	30	4	60	996	*
136	1140	35	35	1070	30	4	60	976	
137	1105	35	35	1035	30	4	60	941	
138	1065	35	35	995	30	4	60	901	
139	1020	35	35	950	30	4	60	856	
140	980	35	35	910	30	4	60	816	
141	935	35	35	865	30	4	30	801	
142	895	35	35	825	30	4	30	761	
143	855	35	35	785	30	4	30	721	
144	810	35	35	740	30	4	30	676	
TOTAL	***141965***	***5040***	***5040***	**131885**	4320	576	2375	**124614**	
Unoccupied	**12710**	**420**	**420**	**11870**	**360**	**48**	**240**	**11222**	*** deduct Unoccupied**
	129255	4620	4620	**120015**	3960	528	2135	**113392**	**Available for Emplacement**

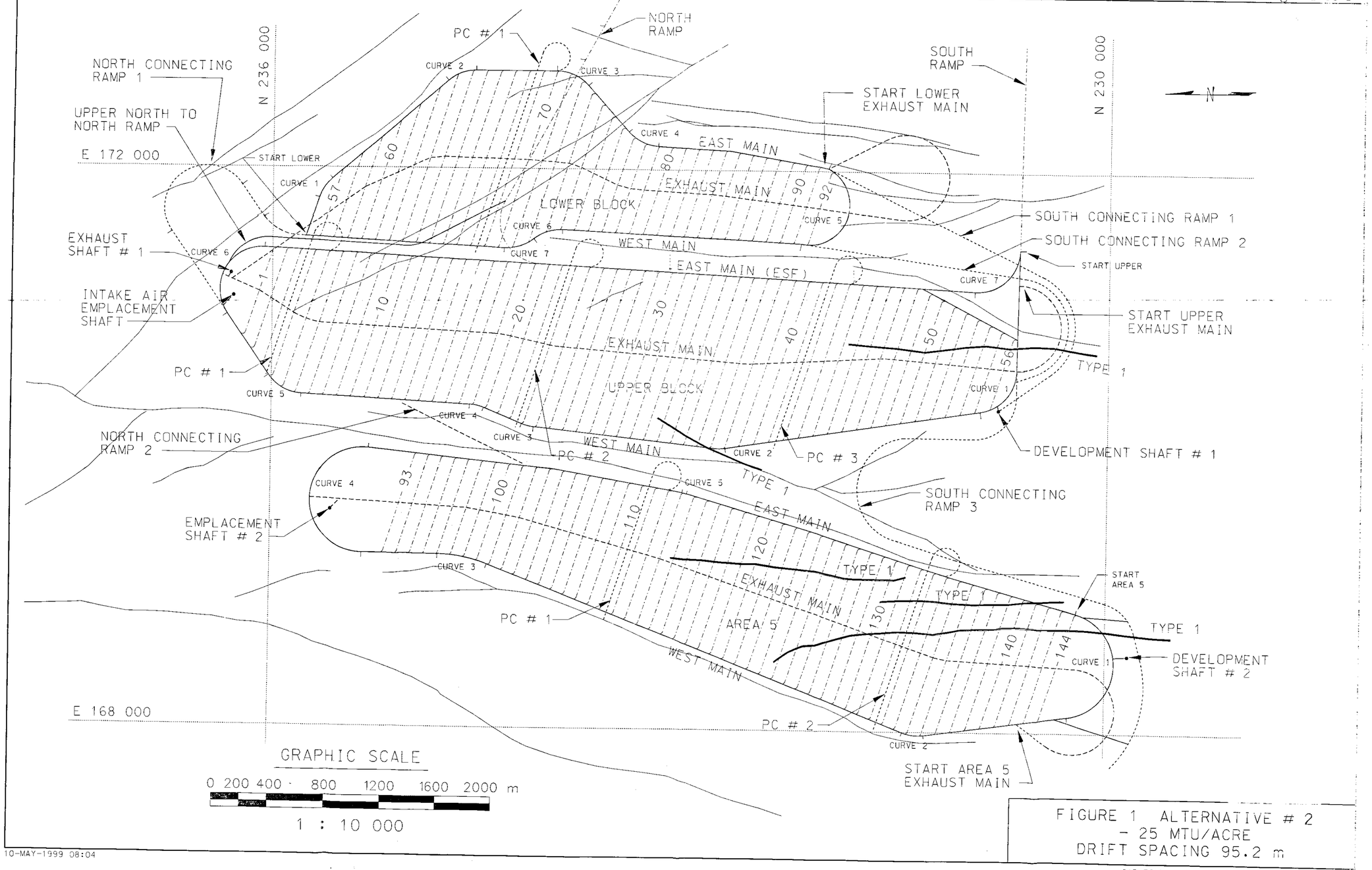

FIGURE 1 ALTERNATIVE # 2 - 25 MTU/ACRE DRIFT SPACING 95.2 m

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